QE
701
J8
Copy 2

Volume 9 OCTOBER, 1935 Number 7

JOURNAL OF PALEONTOLOGY

E. C. CASE
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICH. U. S. A.

A Publication of
The Paleontological Society
An Affiliate of the Geological Society of America
and
The Society of Economic Paleontologists and Mineralogists
A Division of the American Association of Petroleum Geologists

CONTENTS

Nautiloids of the Genus *Aturia* from the Eocene of Texas and Alabama. . *H. B. Stenzel* 551

The Nautiloid Genus *Aturoidea* in America. . . . . *A. K. Miller and M. L. Thompson* 563

Miocene Leaves, Fruits, and Seeds from Idaho, Oregon, and Washington. . . . . *Roland W. Brown* 572

Further Notes on the Cretaceous Pelecypod Genus *Diploschiza*. . . . . *Lloyd William Stephenson* 588

Ordovician Starfish of Wisconsin. . . . . *Jeanette Jones* 593

The Conodont Fauna of the Decorah Shale (Ordovician). . . . . *Clinton R. Stauffer* 596

JOURNAL of PALEONTOLOGY

RAYMOND C. MOORE AND JOHN B. REESIDE, JR.
Editors

ASSOCIATE EDITORS

JOSEPH A. CUSHMAN
Sharon, Massachusetts

G. DALLAS HANNA
San Francisco, California

CARL O. DUNBAR
New Haven, Connecticut

T. WAYLAND VAUGHAN
La Jolla, California

The JOURNAL OF PALEONTOLOGY is published semi-quarterly by the Society of Economic Paleontologists and Mineralogists, a division of the American Association of Petroleum Geologists, and by the Paleontological Society, affiliated with the Geological Society of America.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

Claims for non-receipt of preceding numbers of the JOURNAL must be sent to the Secretary-Treasurer within three months of the date of publication in order to be filled gratis.

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and advertising should be addressed to Gayle Scott, Secretary-Treasurer, Texas Christian University, Fort Worth, Texas.

Communications in regard to manuscripts or purely editorial matters should be addressed to Raymond C. Moore, University of Kansas, Lawrence, Kansas, or John B. Reeside, Jr., U. S. National Museum, Washington, D. C.

Entered as second-class matter at the Post Office at Fort Worth, Texas, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

A Publication of

The Paleontological Society

An Affiliate of the Geological Society of America

and

The Society of Economic Paleontologists and Mineralogists

A Division of the American Association of Petroleum Geologists

VOLUME 9 OCTOBER, 1935 NUMBER 7

CONTENTS

PAGE

Nautiloids of the Genus *Aturia* from the Eocene of Texas and Alabama ..... *H. B. Stenzel* 551

The Nautiloid Genus *Aturoidea* in America ..... *A. K. Miller and M. L. Thompson* 563

Miocene Leaves, Fruits, and Seeds from Idaho, Oregon, and Washington ..... *Roland W. Brown* 572

Further Notes on the Cretaceous Pelecypod Genus *Diploschiza* ..... *Lloyd William Stephenson* 588

Ordovician Starfish of Wisconsin ..... *Jeanette Jones* 593

The Conodont Fauna of the Decorah Shale (Ordovician) ..... *Clinton R. Stauffer* 596

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 551–562, PLS. 63–64, OCTOBER, 1935

NAUTILOIDS OF THE GENUS *ATURIA* FROM THE EOCENE OF TEXAS AND ALABAMA

H. B. STENZEL
Bureau of Economic Geology, Austin, Texas

ABSTRACT

The nautiloid genus *Aturia* is discussed and the subgenera *Aturia*, s. s., *Nilaturia*, and *Brazaturia* are proposed. Three species of *Brazaturia* from the Claiborne group are described.

A study of the stratigraphy and paleontology of the Claiborne group in Texas has been carried on for the last six years, during which time large collections of Claiborne fossils have been accumulated. Many of these fossils are new species that will be described from time to time in convenient groups. The first group treated included the decapod crustaceans (1). The present report considers the species belonging to the nautiloid genus *Aturia*.

Because the Claiborne group of East Texas has been revised recently, it seems advisable to give a short account of its stratigraphy (2). In East Texas, the Claiborne group is represented by thick, non-marine, shaly to silty, lignitic formations that are separated from each other by much thinner, marine, marly to shaly, glauconitic or ferruginous formations. There are eight such formations, named in ascending order: Carrizo sand (non-marine), Reklaw clay (partly marine), Queen City sand (non-marine), Weches glauconite (marine), Sparta sand (non-marine), beds at Stone City (partly marine), Crockett marl (marine), and Yegua formation (non-marine). The beds at Stone City have not yet been defined in the literature as a separate formation. Previous authors have variously included them in the Sparta or the Crockett formation, though the part that carries the species described below has generally been included with the Crockett formation (3). Of the eight units, the Reklaw, Queen City, and Weches are commonly combined as Mount Selman; and the Sparta, the beds at Stone City, and the Crockett, as Cook Mountain. The Carrizo, Mount Selman, and Cook Mountain together are correlated with the lower Claiborne group of Alabama, and the Yegua formation with the upper Claiborne group (Gosport sand) of Alabama. In some places, however, as in Brazos, Burleson, and Lee counties, the lower part of the Yegua formation contains marine lentils with a fauna of lower Claiborne aspect, according to Gardner (4) and Renick and Stenzel (5). The Claiborne group as a whole is thought to correspond to the Lutetian and Auversian of Europe (6).

Aturia has been found in the Claiborne group of Texas, in the Weches formation, in the beds at Stone City,

and in the Crockett formation. The Weches formation yielded *Aturia* (*Brazaturia*) *triangula* Stenzel, n. sp., *A.* (*B.*) *laticlavia* Stenzel, n. sp., and *A.* (*B.*) *brazoensis* Stenzel, n. sp. The beds at Stone City yielded *A.* (*B.*) *brazoensis*. The Crockett formation yielded only one very fragmentary specimen. The other, largely nonmarine, formations very probably do not contain any fossil cephalopods in this region. *Aturia* is not known from deposits older than Claiborne in the Gulf Coast region.

Acknowledgments.—The writer is very much indebted to the Bureau of Economic Geology in Austin, Texas, and its director, Dr. E. H. Sellards, for the use of photographic equipment and the loan of a specimen. Thanks are due to Mr. F. B. Plummer for advice in photographic methods. For the specimens of *Aturia praeziczac* the writer is very grateful to Dr. Paul Oppenheim of Berlin. Dr. Paul Bartsch of the U. S. National Museum and Dr. W. B. Jones of the Alabama Museum of Natural History are thanked for their kind permission to study specimens in the respective museums. Dr. Julia Gardner has extended valuable help during the writer's visits to the U. S. National Museum.

The National Research Council, Washington, D. C., has made this work possible through a grant-in-aid. The writer gratefully acknowledges this aid.

The manuscript of this paper was received by the editor of the Journal February 15, 1934.

BIOSTRATIGRAPHIC SIGNIFICANCE

The species of *Aturia* in the Weches formation are rare and in fragmentary condition. That they were fragmentary before their burial in the sediments is shown clearly by the specimens, for many do not have the living chamber preserved, and all have broken air chambers and incomplete whorls. This is in agreement with the sublittoral character of the Weches deposits.

In the beds at Stone City the specimens are often complete, though crushed by the load of the overlying sediments. *Aturia brazoensis* is by no means rare at Stone City, but uninjured individuals are. The specimens represent various ages, from nepionic to gerontic.

In the zone of the Crockett formation that starts with the Moseley limestone bed and includes the beds exposed at the Little Brazos locality, Brazos County, no specimens of *Aturia* have been found, in spite of long, careful search in several excellent outcrops and in spite of the fact that even small shell fragments are easily recognized by their bluish-

---

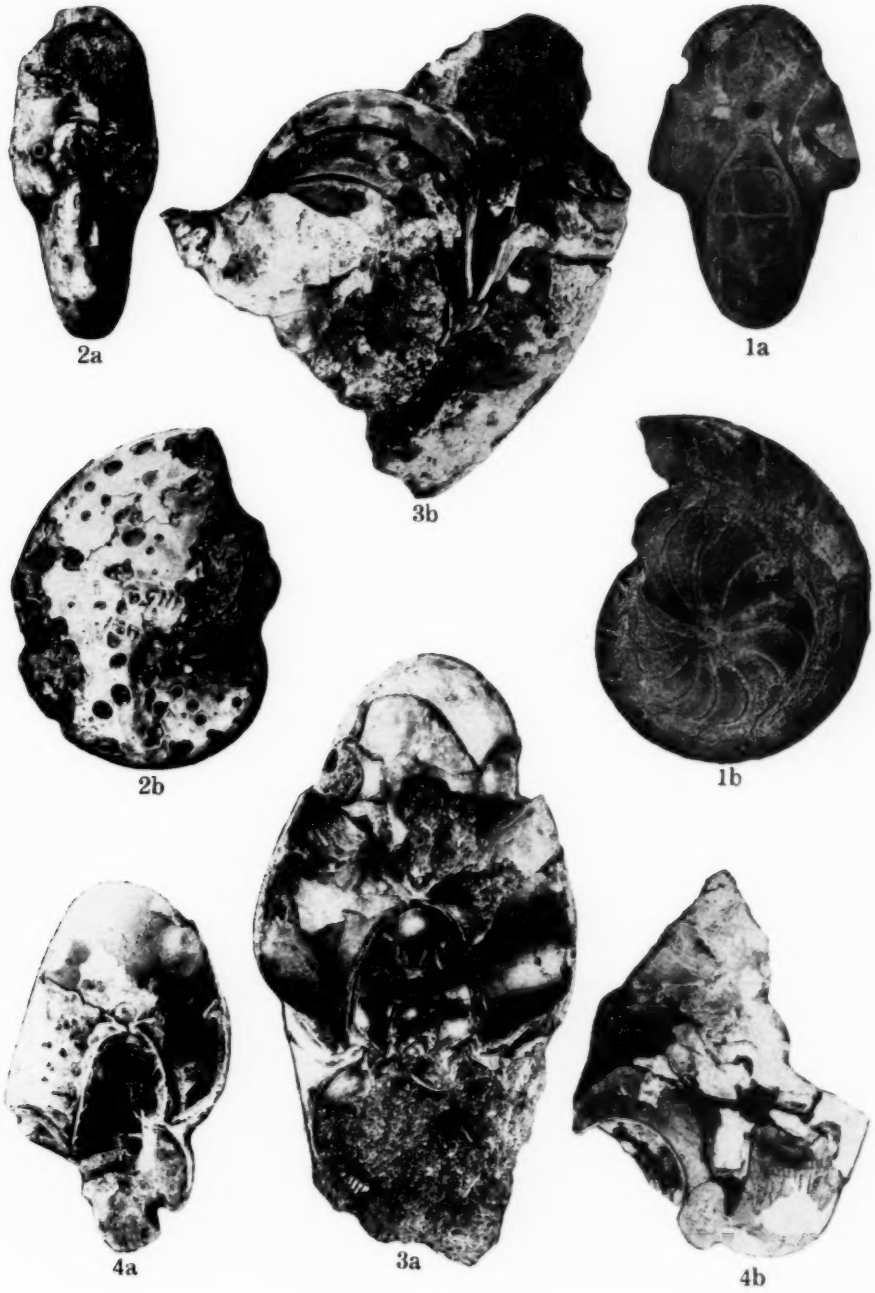
EXPLANATION OF PLATE 63

FIGS. 1*a*, *b*—*Aturia* (*Nilaturia*) *praeziczac* Oppenheim, ×2; 1*a*, ventral view; 1*b*, lateral view; Esneh shale, "Schech-Abd-el-Ourun," near Thebes, Egypt. (p. 554)

2*a*, *b*—*Aturia* (*Brazaturia*) *alabamensis* (Morton), ×1; 2*a*, ventral view; 2*b*, lateral view, Moodys marl, Jackson, Hinds County, Mississippi. (p. 556)

3*a*, *b*—*Aturia* (*Brazaturia*) *triangula* Stenzel, n. sp., holotype, ×⅔; 3*a*, ventral view; 3*b*, lateral view; Weches formation, Bald Mound, near Centerville, Leon County, Texas. (p. 557)

4*a*, *b*—*Aturia* (*Brazaturia*) *laticlavia* Stenzel, n. sp., holotype, ×⅔; 4*a*, ventral view; 4*b*, lateral view, Weches formation, Bald Mound, near Centerville, Leon County, Texas. (p. 558)



Stenzel, Eocene Nautiloids

green nacreous luster. Higher up in the Crockett formation, in marine beds interbedded with lignitic shales, one fragmentary specimen was found.

These facts seem to indicate that in Weches time species of *Aturia* were not indigenous in this region, but floated in as dead, empty shells from the deeper parts of the Gulf of Mexico. These shells sank after being broken, probably by wave action. It seems unlikely that the shells were broken by scavenger or carnivorous animals, because there could hardly have been any edible material in the air chambers, and these are broken in all specimens available for study.

In the time of the beds at Stone City *Aturia* was thriving and indigenous to the region. After the deposition of the Moseley limestone bed, which marks the top of these beds, *Aturia* disappeared from the region, and even dead fragmentary shells did not float in during the earlier part of the Crockett time. Later in Crockett time *Aturia* reappeared, only to disappear again with the withdrawal of the sea at the beginning of Yegua time. With the transgression of the Jackson *Aturia* reappeared once more in Texas as *A. alabamensis* (Morton).

SYSTEMATIC DESCRIPTIONS

Order NAUTILOIDFA

Family ATURIIDAE

Genus ATURIA Bronn, 1838

Aturia BRONN, *1838*, Leathea geognostica, vol. 2, pp. 1122–1123, pl. 42, figs. 17 a–c. (Not *Aturia* Gray, 1840, a reptile, Agassiz, Nomenclator Zoologicus, 1842.)

Etymology: *Aturus*, Roman name for River Adour, Department of Landes, France. The Celtic radical *dour* means water.

Genotype: *Nautilus aturi* Basterot (Descriptions des coquilles fossiles des environs de Bordeaux: Soc. Hist. Nat. Paris, Mém., vol. 2, pt. 1, pp. 12, 17–18, 1825). Burdigalian of St. Paul de Dax, Department of Landes, France.

Generic definition: Shell nautiloid, completely involute, non-umbilicate. Septa numerous, with a deep lateral lobe; the dorsal part of the septa prolonged backwards, forming long, funnel to pipe-shaped siphonal collars around the centrodorsan to subdorsan siphuncle.

Geologic range: Mostly Eocene to Miocene; the genus has, however, been reported from the Danian of Egypt—*A. praeziczac* Oppenheim and *A. thebensis* Oppenheim (7); from the Cretaceous Chico formation of California—*A. dickersoni* Schenck (8); from supposed Cretaceous of New Jersey—*A. paucifex* Cope (9); and from questionable lower Pliocene of Australia (10).

Aturia paucifex Cope from the Hornerstown marl of New Jersey, which was considered Cretaceous by Cope, Whitfield (11), and Weller (12), is a lower Eocene species, as has been shown by Cooke and Stephenson (13). It does not belong to the genus *Aturia* but to *Aturoidea* Vredenburg (= *Paraturia* Spath).

The two Egyptian species of *Aturia* from the Blättermergel, or Esneh shale, of Thebes, Egypt, occur together with a faunule consisting chiefly of casts of pelecypods and gastropods. This faunule was discussed by Oppenheim, who considered it Danian (14). Others, as for instance, d'Archiac (15), Beadnell (16), and Boussac (17), placed it in the lower Eocene. In the absence of ammonites and typically Cretaceous gastropod or pelecypod genera it seems not convincing that this faunule belongs to the

Danian. There appears no reason not to consider it lower Eocene in age. However, the two species of *Aturia* of this faunule are primitive. They represent in my opinion a subgenus of *Aturia* that points to the ancestral form of the Aturiidae (see also p. 555). It would seem, therefore, that the question of the age of the Esneh shale must remain open until further evidence is collected in the field.

Subgenus ATURIA Bronn, s. s.

Subgenotype: *Aturia aturi* (Basterot).

Subgeneric definition: Siphonal collars large, funnel-shaped, and touching the dorsum; siphuncle centrodorsan.

Remarks.—Concerning the siphuncle and the siphonal collars of this subgenus, it may be best to quote an observation of Foord (18):

> From the strong contraction of the siphuncle (19) it follows that, although its aperture rests on the edge of the septa, its narrow extremity is not in contact with the shell-wall. In this respect the siphuncle of *Aturia* differs from that of *Clymenia* and the Ammonites.

The axis of the siphuncle is centrodorsan in position and does not adjoin the dorsum as in the subgenera *Nilaturia* and *Brazaturia*. This distinction is observable in shells of equal size, so that a fair comparison may be made. Lack of sufficiently clear figures and descriptions in the literature and of specimens for comparison forbids me to assign any other species than *A. aturi* to *Aturia*, s. s., at present. It is very difficult to determine the position of the siphuncle in illustrations, for many are not made so that the line of sight falls in the direction of axis of the siphuncle. In such illustrations the siphuncle appears out of place, as, for instance, in Pl. 64, fig. 1*a*. This specimen has a subdorsan siphuncle.

Subgenus NILATURIA Stenzel, n. subgen.

Etymology: *Nilus*, the Nile, and *Aturia*.

Genotype: *Aturia praeziczac* Oppenheim (Über die Fossilien der Blättermergel von Theben: K.-bayer. Akad. Wiss., Sitzungsb., vol. 32, pp. 436–438, pl. 7, figs. 1–3, 1902).

Subgeneric definition: Siphonal collars narrow, three-fifths the depth of a chamber in length; siphuncle subdorsan; lateral lobe of suture rounded and not very deep; median dorsal lobe deep and wide, adjoining the siphuncle.

Remarks.—Professor Paul Oppenheim had the kindness to send the writer five specimens of *Aturia praeziczac* from Schech-Abd-el-Ourun, near Thebes, collected by Schweinfurth in 1902–1903. The discussion of the species given below is based on these specimens.

The siphonal collars of *A. praeziczac* are unusually small for *Aturia*. They have the same diameter as those in individuals of the same size of *Eutrephoceras "dekayi* (Morton)" from the Cretaceous of Mingusville, Montana—about the normal diameter of nautiloid siphonal collars and not as exaggerated and funnel-shaped as in *Aturia*, s. s. The collars are also not very long, not reaching from one septum to the next preceding one, but occupying merely three-fifths of the depth of one chamber. The collars are not invaginated, therefore, one into the other. The shape of the collars is rather pipe-like than funnel-like, as the taper is very slight. At the apical end they contract abruptly so that the lumen is reduced to two-thirds or one-half.

The suture is simpler than in other subgenera at the same size; lateral lobe plump and rounded at the tip; tip not hooked back, but with slight concavity on its dorsal side; large median dorsal lobe that reaches down to the siphuncle (Fig. 4). In the subgenus *Brazaturia* the sides of this lobe are coalesced and the lobe almost entirely closed. Through this coalescence the siphuncle has been removed far from the suture and is situated below or deeper than the suture and yet adjoining the dorsum (Pl. 64, fig. 1*a*).

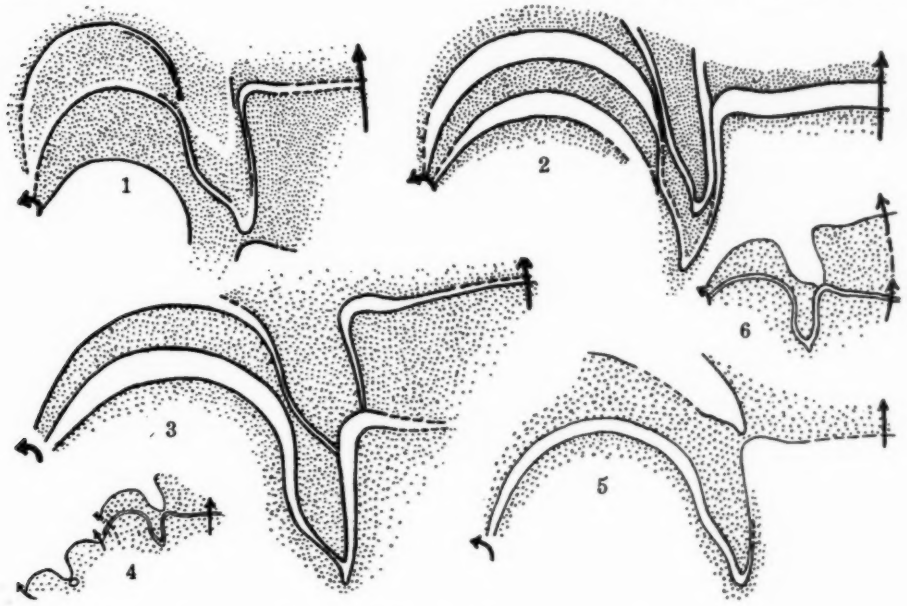
All the characteristics of *Nilaturia* are primitive and point back to the ancestral form of *Aturia*. Though the subgenus belongs to *Aturia* rather than to *Hercoglossa*, it stands very near to *Hercoglossa*. *Brazaturia* stands between *Nilaturia* and *Aturia*, s. s., in evolutionary development.

Subgenus BRAZATURIA Stenzel
n. subgen.

Etymology: Brazos River and *Aturia*.

Subgenotype: *Aturia* (*Brazaturia*) *brazoensis* Stenzel, n. sp.

Subgeneric definition: Siphonal collars moderate; siphuncle subdorsan; lateral lobe of suture deep and pointed; median dorsal lobe closed and rudimentary.



FIGS. 1–6—Suture diagrams of species of *Aturia*, ×¾.
1—*Aturia* (*Brazaturia*) *laticlavia* Stenzel, n. sp., holotype. (p. 558)
2—*Aturia* (*Brazaturia*) *triangula* Stenzel, n. sp., holotype. (p. 557)
3—*Aturia* (*Brazaturia*) *brazoensis* Stenzel, n. sp., paratype 4. (p. 559)
4—*Aturia* (*Nilaturia*) *praeziczac* Oppenheim, topotype. (p. 554)
5—*Aturia* (*Brazaturia*) *alabamensis* (Morton), specimen from U. S. Geological Survey station 12,559. (p. 556)
6—*Aturia* (*Brazaturia?*) *lingulata* (von Buch), Lutetian of Kressenberg near Teisendorf, Upper Bavaria; U. S. Nat. Mus. 369,746. (p. 556)

The nautiloids usually have thick septal walls. Therefore, each suture is not a thin line but a more or less broad band. In the text figures the sutural bands are left white, and the chamber space between two succeeding sutures is stippled. Each suture consists of two more or less parallel lines, the one showing the trace of the upper or outer surface of the septal wall, the other the trace of the lower or inner surface. Both lines delimit the sutural band and are shown in the figures.

Aturia praeziczac did not reach large size, the largest of the five specimens at hand having a diameter of 30.5 mm. It must have been somewhat larger originally, because the last chambers are not preserved. All specimens are limonitized pyritic micromorphs.

Remarks.—Beside the three new species described below there seem to belong here *A. alabamensis* (Morton) (20) and *A. vanuxemi* (Conrad) (21).

Sphenaturia Von Ihering (22) may be an earlier name for this subgenus, but

Von Ihering described and figured only the sutures and external features of his specimens, omitting a detailed description of the siphuncle, and it is not possible to decide the question without consulting the types. Presumably most or all Eocene species of *Aturia* belong in the subgenus *Brazaturia*.

It is well known that species of *Aturia* are difficult to distinguish because of their lack of ornamentation. Possibly too many species have been named, and one suspects that in some cases sexual differences have been considered specific differences. This may be true of *A. praeziczac* Oppenheim and *A. thebensis* Oppenheim (23). On the other hand, a lumping of species such as that advocated by Geinitz (24), who considered *A. alabamensis* (Morton), *A. ziczac* (Sowerby), and *A. lingulata* (Von Buch) (Fig. 6) as conspecific, is of no value to stratigraphic and paleontologic work. As conditions are at present, it is best to describe separate species until enough of these rare cephalopods have been collected to allow a revision. I believe that the new species described below are as well defined as any of this genus, though perhaps *A. brazoensis*, n. sp., represents two new species, one in each of the two horizons.

Aturia vanuxemi (Conrad) and *Aturoidea paucifex* (Cope) have been redescribed by Whitfield (25), and his monograph is readily available. For this reason and for comparison with the new species *A. alabamensis* only is redescribed below. Several references to indeterminate species of *Aturia* from the Eocene of the Gulf Coastal Plain will not be considered here. Moore (26) refers to a "*Nautilus zigzag*" from Vaiden Station, near Shongalo, Carroll County, Mississippi. What species this represents is not known. Harris (27) figures an *Aturia* in an unpublished manuscript. This specimen, from the basal Weches at Collier's Ferry on the Brazos River, Burleson County, Texas, belongs probably to one of the three new species described below. An indeterminate fragment from the same locality is in the Harris Collection of the Department of Geology, University of Texas, Austin, Texas.

ATURIA (BRAZATURIA) ALABAMENSIS (Morton)

Plate 63, figures 2*a-b*; text-figure 5

Nautilus alabamensis MORTON, *1834*, Synopsis of the organic remains of the Cretaceous group of the United States, p. 33, pl. 18, fig. 3.—MORTON, *1842*, Acad. Nat. Sci. Philadelphia, Jour., ser. 1, vol. 8, p. 217.—ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, p. 43.

Nautilus alabamiensis COSSMANN, *1893*, Ann. Géol. Paléont., livr. 12, p. 51.

Aturia sp., EDWARDS, *1849*, Monograph of the Eocene Mollusca, pt. 1, Cephalopoda, Paleontogr. Soc., Mon., pp. 52, 55.

Aturia alabamensis (Morton), CONRAD, *1865*, Am. Jour. Conchology, vol. 1, p. 15.—CONRAD, *1866*, Smithsonian Misc. Coll., vol. 7, no. 200, p. 26.—COOKE, *1916*, U. S. Geol. Survey, Prof. Paper 95, pp. 111, 116–117.—HOPKINS, *1918*, U. S. Geol. Survey, Bull. 661, p. 296, pl. 27, fig. 1.—COOKE, *1926*, Alabama Geol. Survey, Spec. Rept. 14, pl. 96, fig. 6.—KELLUM, *1926*, U. S. Geol. Survey, Prof. Paper 143, pp. 7–8, 11, 32.—SCHENCK, *1931*, Univ. California Dept. Geol. Sci., Bull., vol. 19, no. 19, pls. 77–78.—ALDRICH, *1931*, Alabama Geol. Survey, Mus. Paper 12, p. 7, pl. 4.—GARDNER, *1932*, in Trowbridge U. S. Geol. Survey, Bull. 837, pl. 43, figs. 4–5.

Aturia (near *alabamensis* Morton), DALL, *1903*, Wagner Free Inst. Sci. Philadelphia, Trans., vol. 3, pt. 6, p. 1557.

Aturia ziczac (Sowerby) (part), GEINITZ, *1887*, Neues Jahrb., vol. 2, pp. 53–56, pl. 3.

Aturia ziczac (Sowerby)? +*Nautilus? alabamensis* Morton, DE GREGORIO, *1890*, Ann. Géol. Paléont., livr. 7–8, pp. 14–15, pl. 1, figs. 37, 38*a*, 38*b*.

Shell involute, compressed. Cross-section of whorl in young stage high, narrow, widest at umbilical shoulder; umbilical shoulder rather indistinct. Umbilical zone narrow, occupying about one-seventh of the total height of the whorl; lateral zones converging at 23° to 30°, appearing almost flat and parallel to a line much beyond the region of the lateral lobes; venter regularly and sharply rounded.

Septa convex apicad, broadly invagi-

nated by the lateral lobes, less so for the large siphuncle. Septa few, 13 in the last whorl of the specimen figured by Schenck. Sutures fairly straight across the venter; a small saddle at the ventral corner of the base of the lateral lobe; lateral lobes slender, long, pinched in at the point, which is recurved dorsally. Successive sutures almost touch where the point of the lateral lobe approaches the ventral basal corner of the preceding lateral lobe.

In a specimen belonging to the Bureau of Economic Geology the shell is preserved; it has a shallow spiral groove at the line of the lateral lobe. Growth lines crowded. Hyponomic sinus sharply curved.

The specimen of the Bureau of Economic Geology differs considerably from the larger specimens inspected, but this seems to be due mostly to its youth. This specimen is more compressed than the adults.

Dimensions: Most specimens of this species are white limestone moulds that have been pressed out of shape by rock pressure. For instance, the specimen figured by Schenck and Aldrich, belonging to the Alabama Museum of Natural History, is much appressed laterally. The specimen in the Bureau of Economic Geology, Austin, Texas, has retained its shape perfectly, its dimensions being: diameter, 46 mm.; height of last preserved whorl, 30 mm.; median height, 19.5 mm.; greatest thickness, 19.3 mm. A specimen from U. S. Geol. Survey Sta. 12559: height of whorl, 68 mm.; greatest thickness, 48 mm.

Remarks.—*Aturia alabamensis* (Morton) differs from the three new species described below in its narrow and high cross-section in the young stage. This same feature makes itself manifest also in the compressed form of the whole shell, in the low angle of convergence of the lateral zones, and the flatness of the lateral zones.

Specimens.—This description is based chiefly on a specimen in the Bureau of Economic Geology, Austin, Texas; and on a specimen in the writer's collection from the quarry of Marianna Lime Products Company, near Marianna, Jackson County, Florida.

Localities.—Morton's type and the specimens described by Geinitz came from Claiborne, Alabama; the specimen in the Bureau of Economic Geology from the bed of Moody's Branch near the bridge in Jackson, Mississippi (Rio Bravo Oil Co. Coll. R.489). Kellum mentions Wilmington, New Hanover County; and Old Rocky Point, Pender County, North Carolina.

Material has been examined from the following localities: Near Suggsville, on road between Suggsville and Gosport, Clarke County, Alabama, specimen figured by Schenck and Aldrich (Alabama Mus. Nat. Hist.). Cocoa Post Office, Choctaw County, Alabama, collected by Schuchert and Burns, 1894 (U. S. Geol. Survey Stas. 2637, 2892; U. S. Nat. Mus. 141,101, 141,102). Near Cocoa, SW. ¼ sec. 13, T. 11 N., R. 5 W., Choctaw County, Alabama, collected by Cooke, 1914 (U. S. Geol. Survey Sta. 7219). Property of L. B. Batson in NE. ¼ sec. 8, T. 9 N., R. 4 W., 5 miles west of Silas, Choctaw County, Alabama (U. S. Nat. Mus. 370,816). Sec. 17, T. 1 N., R. 18 E., Clarke County, Mississippi (U. S. Geol. Survey Sta. 12,559). Jackson, Mississippi (U. S. Geol. Survey Sta. 64; U. S. Nat. Mus. 136,680). Hacienda 5 km. south of El Azucar, Camargo district, Tamaulipas, Mexico (Coll. 5146, Sta. 277).

Geologic horizon.—Castle Hayne marl in North Carolina, Ocala limestone in Florida and Alabama, "*Zeuglodon* beds" in Alabama, Moodys marl in Mississippi, "Fayette" sandstone in Mexico; all in Jackson group, upper Eocene.

ATURIA (BRAZATURIA) TRIANGULA Stenzel, n. sp.

Plate 63, figures 3*a*, *b*; text-figure 2

Etymology: *Triangulus*, triangular, referring to the somewhat triangular cross-section of the whorls.

Description of holotype: The specimen is a fragment containing sectors of five successive whorls. Shell of last preserved whorl involute, widest at the umbilical shoulder, of roughly triangular cross-section; the narrow umbilical zone occupying about one-eleventh of the total height of the whorl. Umbilical shoulder distinct; sides straight from the umbilical shoulder to beyond the lateral lobes, converging at an angle of 40°; venter regularly and rather sharply rounded. Penultimate whorl inflated, much less triangular in cross-section, as the straight sides are proportionately shorter and the curvature of the venter proportionately gentler. Cross-section of the third whorl similar to the fourth or penultimate. Second whorl almost crescentic in cross-section, owing to the extreme shortness of the straight sides, which extend from the umbilical shoulder to the region of the lateral lobes. First whorl almost globular.

Septa convex apicad, broadly invaginated for the lateral lobes, less so for the siphonal collars; numerous, probably 22 in the last preserved whorl. Sutures nearly straight across the venter, with small saddle at ventral base of lateral lobe; lateral lobes slender, long, gently tapering, pinched in near the point; lateral saddles uniformly curved. Successive sutures touch or almost touch at several places along the lateral lobes.

Most of the growth lines are not observable.

Dimensions: First whorl, height, 2 mm.; second whorl, height, 4 mm., median height, 2.5 mm., greatest thickness, 4 mm.; third whorl, height, 12 mm., median height, 7 mm., greatest thickness, 9 mm.; fourth whorl, height, 30 mm., median height, 19 mm., greatest thickness, 24 mm.; fifth whorl, height, 78 mm., median height, 50 mm., greatest thickness, 64 mm. Length of lateral lobe in last (fifth) whorl, 34 mm., width at base, 11 mm.

Remarks.—This species differs from the other species of *Aturia* described below in its nearly triangular and less inflated cross-section and the greater number of septa per whorl. The septa are also more crowded and have longer and more slender lateral lobes.

Types.—Holotype and one paratype in the writer's collection, Bureau of Economic Geology, Austin, Texas.

Type localities.—Bald Mound in H. R. Benson 70 acres, Robert Wood survey, 4.3 miles northwest of Centerville, Leon County, Texas (holotype). North ditch of Robbins-Centerville road, 0.6 mile southeast of Robbins, in south corner of J. M. Powell 100 acres, in south corner of R. M. Tyus survey, Leon County, Texas (paratype).

Geologic horizon.—Middle Eocene, Claiborne group, Weches formation. Holotype found in limestone A at Bald Mound.

Aturia (Brazaturia) laticlavia Stenzel, n. sp.

Plate 63, figures 4*a–b;* text-figure 1

Etymology: *Laticlavius*, broad-striped, referring to the broad and short lateral lobes.

Description of holotype: The specimen is a sectoral fragment containing parts of two whorls. Shell of last whorl involute, widest at a point one-fourteenth of the height of the whorl removed from the umbilicus; widest point not at umbilical shoulder, but about twice the width of the umbilical zone removed from the umbilicus; sides gently curved from the umbilical shoulder to beyond the lateral lobes, converging approximately at an angle of 36°; venter regularly and rather sharply rounded. The penultimate whorl does not appear any more inflated than the last whorl.

Septa convex apicad, broadly invaginated for the lateral lobes, less so for the subdorsan siphuncle; fairly numerous, probably 18 to 21 in the last whorl. Suture straight across the venter; lateral lobes fairly broad, short, at one place almost parallel-sided and pinched in at the end; lateral saddles very highly arched.

Growth lines not observable in this specimen.

Dimensions: Height of first preserved whorl, 19 mm., greatest thickness, 15 mm.; height of second preserved (or last) whorl, 55 mm., median height, 32 mm., greatest width, 42 mm. Length of lateral lobe in last whorl, 23 mm., width at base, 9 mm.

Remarks.—This species differs from *A. triangula* in its broader, more inflated cross-section; the lower number of septa per whorl; and the much shorter, plumper, lateral lobes. From *A. brazoensis* it differs not so much in the shape as in the sutures. The very highly arched lateral saddle is not found in the other two new species.

Type.—Holotype in the writer's collection, Bureau of Economic Geology, Austin, Texas.

Type locality.—Bald Mound in H. R. Benson 70 acres, Robert Wood survey, 4.3 miles northwest of Centerville, Leon County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Weches formation, limestone A.

ATURIA (BRAZATURIA) BRAZOENSIS

Stenzel, n. sp.

Plate 64; text-figure 3

Hercoglossa, n. sp., STENZEL, *1931*, in Renick and Stenzel, Univ. Texas, Bull. 3101, pp. 94–95, 99.

Etymology: Brazos River, on which the holotype was found.

Holotype: A nearly complete neanic shell, lacking only the living chamber. Shell involute and high; cross-section of last whorl compressed-oval, widest at a place three-tenths of the total height removed from the umbilicus. Umbilical shoulder not well defined; umbilical zone occupying about one-eighth the total height of the whorl. Lateral zones converge at an angle of 44°, nearly flat, short; venter somewhat narrowly rounded.

Last septum convex apicad, broadly invaginated for the lateral lobes, less so for the siphonal collars. Septa not numerous, largely hidden by shell material, probably 17 in the last whorl.

Growth lines well preserved; hyponomic sinus deep and sharply curved.

Paratype 2: A small shell partly broken open and with the greater part of the living chamber preserved. Shell involute and high; cross-section of last whorl, at a place one-half volution removed from the original aperture, less broad than in the holotype (apparently due to the much younger age of this paratype); greatest width at the umbilical shoulder, which is not well defined. Umbilical zone occupies about one-ninth of the total height of the whorl; lateral zones converge at an angle of 36°, nearly flat; venter less broadly rounded. Earlier cross-sections very similar in outline.

Septa convex apicad, broadly invaginated for the lateral lobes, less so for the siphonal collars; few, probably 14 in the last whorl. Sutures not visible, because they are covered by the nacreous outside shell, but may be inferred from the septa.

Growth lines well preserved; hyponomic sinus at venter deep and sharply curved; lateral parts of the growth lines highly curved.

Paratype 3: A nearly entire shell without the living chamber, embedded in hard glauconite marl; in gerontic stage, involute, large, and plump. Cross-section of last whorl broad oval, widest at umbilical shoulder; umbilical shoulder rather indistinct. Umbilical zone occupies about one-eighth of the total height of the whorl; lateral zones converge at 43°, gently arched to flat, extending from the shoulder to a little beyond the region of the lateral lobes; venter broadly rounded. Cross-section of the stage which is one-half volution earlier, i.e., diametrically opposite to the above described one, much narrower but otherwise very similar to it; also very similar in cross-section to paratype 4.

Septa convex apicad, broadly invaginated for the lateral lobes, less so for the siphonal collars; not very numerous, probably 14 in the last whorl. Suture straight across the venter; lateral lobes broad, at first parallel-sided, then rapidly tapering and pinched in at the end; lateral saddles rather flat, less arched than in *A. triangula* and *A. laticlavia;* successive sutures almost touch (2 mm. distance) at one place. Suture and lateral lobes very similar in the earlier stage above referred to.

Growth lines, as far as preserved, as usual in this genus.

Paratype 4: An internal mold of glauconitic limestone showing almost the entire living chamber and one-half of the preceding whorl; shell substance preserved originally but removed by blow pipe for the study of the sutures. Shell involute, large, and high; living chamber occupying about three-eighths of the last whorl. Cross-section of the last whorl less broad than in paratype 3 at its last preserved septum, though at the same diameter in both types, of very nearly the same shape; greatest width at umbilical shoulder, which is fairly well defined. Umbilical zone occupying about one-seventh of the total height of the whorl; lateral zones converging at an angle of 37°, nearly flat; venter medium-rounded.

Septa not numerous, probably 16 in the last whorl. Suture straight across the venter, with small saddle at the corner between lateral lobe and ventral region; lateral lobes broad, for a short distance parallel-sided, then rapidly tapering, pinched in at the end. Successive sutures touch, the last one even overlaps the penultimate. Lateral saddles uniformly but gently curved.

Paratype 4 differs somewhat from the other types and comes from another formation. The differences are minor and it has been left in this species. However, the last two septa are crowded together more than the preceding septa, indicating that the individual approached its end of growth and therefore probably could not have reached the large size of the gerontic paratype 3.

Dimensions: Holotype, diameter, 102 mm.; height of last preserved whorl, 62 mm.; median height, 42 mm.; greatest thickness, 51 mm. Paratype 2, height of last preserved whorl, 33 mm.; greatest thickness, 28 mm.; height of whorl at last septum, 23 mm.; median height, 14 mm.; greatest thickness, 21 mm. Paratype 3, diameter, about 240 mm.; height of last preserved whorl, 136 mm.; median height, 91 mm.; greatest thickness, 22 mm. Paratype 4, diameter, 171 mm.; height of living chamber, 106 mm.; greatest thickness, 79 mm.

Remarks.—This species is easily distinguished from *A. alabamensis* and *A. triangula* by its fairly broad, inflated cross-section; from *A. laticlavia* by its less highly arched lateral saddle and other features of the suture.

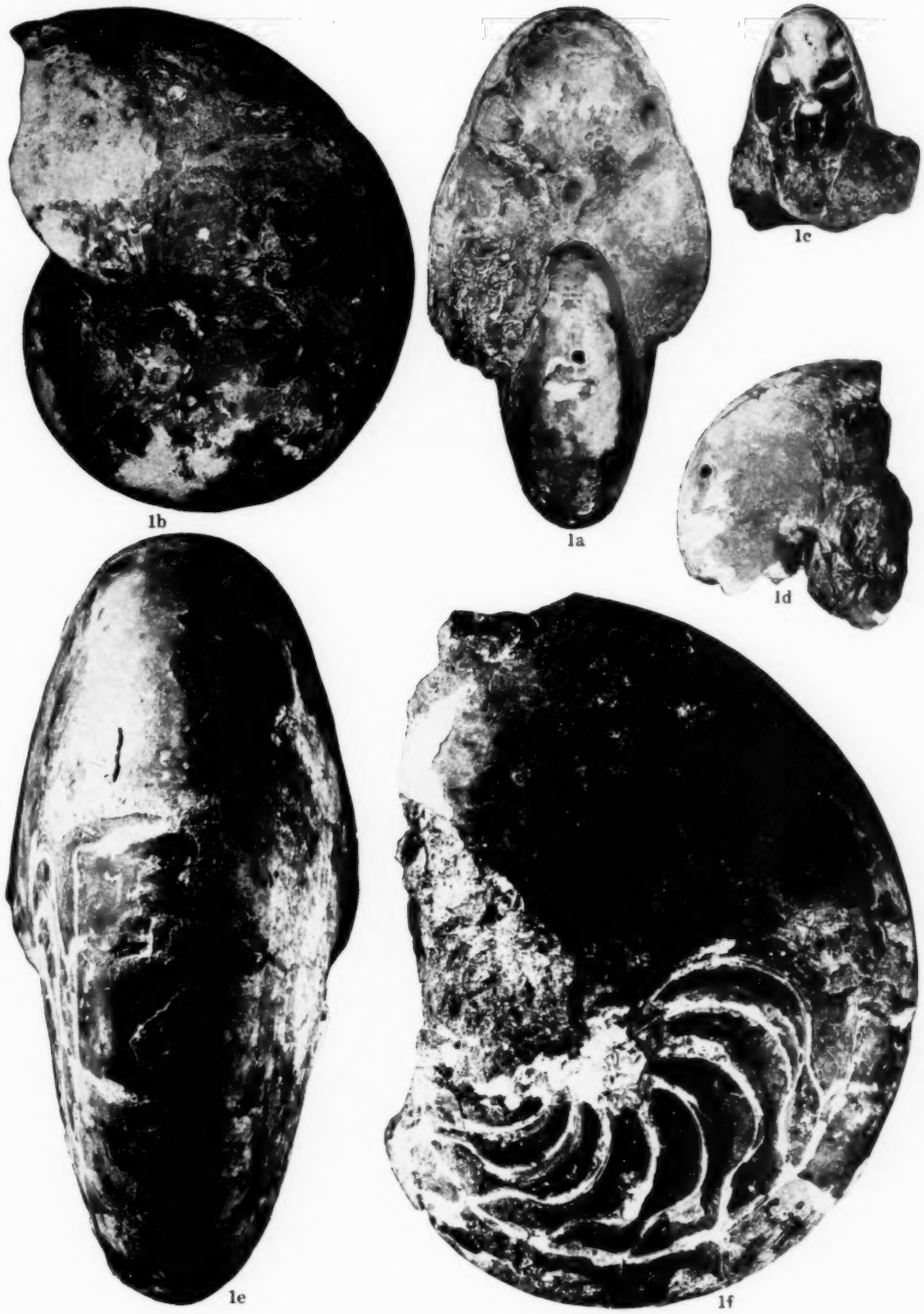
Types.—Holotype, paratypes 2 to 5 and other fragmentary paratypes in the writer's collection in the Bureau of Economic Geology, Austin, Texas.

Type localities.—Stone City (or Moseley's Ferry) on the Brazos River, i.e., the bluff on the right bank and directly upstream from the bridge of the new State Highway 21 and the bridge of the Southern Pacific Railroad, Burleson County, Texas (holotype and all paratypes except 4). About 0.1 mile south of wooden bridge over McDonald Creek, in road running along boundary between

---

EXPLANATION OF PLATE 64

FIGS. 1*a–f*—*Aturia* (*Brazaturia*) *brazoensis* Stenzel, n. sp. 1*a*, Ventral view; 1*b*, lateral view of holotype, ×¾; 1*c*, ventral view; 1*d*, lateral view of paratype 2, ×¾; beds at Stone City, Burleson County, Texas. 1*e*, Ventral view; 1*f*, lateral view of paratype 4, ×½; Weches formation, McDonald Creek, near Centerville, Leon County, Texas. (p. 559)



Stenzel, Eocene Nautiloids

B. Middleton and John Beauchamp surveys, in southwest corner of J. H. Cook 150 acres, southwest corner of John Beauchamp survey, 6.3 miles west-southwest of Centerville, Leon County, Texas (paratype 4).

Geologic horizon.—Middle Eocene, Claiborne group, Weches formation, limestone A (paratype 4); and beds at Stone City, 5 to 19 feet below the Moseley limestone bed of the Stone City section. This species is restricted to the following glauconite marls of the Stone City section: Glauconitic marl in basal shale, bed (*a*) of Stenzel (28); main glauconitic marl, bed (*b*) of Stenzel; and 19-inch glauconitic marl, bed (*d*) of Stenzel. Fragments of crushed nautiloid shells, probably belonging to this species, are fairly common in these three layers.

REFERENCES

1. STENZEL, H. B., Decapod crustaceans from the Middle Eocene of Texas: *Jour. Paleontology*, vol. 8, pp. 38–56, 1934.
2. WENDLANDT, E. A., and KNEBEL, G. M., Lower Claiborne of east Texas: *Am. Assoc. Petr. Geol., Bull.*, vol. 13, pp. 1347–1376, 1929; ELLISOR, A. C., Correlation of the Claiborne of east Texas with the Claiborne of Louisiana: *idem*, vol. 13, pp. 1335–1346, 1929; RENICK, B. C., and STENZEL, H. B., The lower Claiborne on the Brazos River, Texas: *Univ. Texas, Bull.* 3101, pp. 73–108, 1931; SELLARDS, E. H., ADKINS, W. S., and PLUMMER, F. B., The geology of Texas, vol. 1, stratigraphy: *Univ. Texas, Bull.* 3232, pp. 606–677, 1932.
3. STENZEL, H. B., A new formation in the Claiborne group: *Univ. Texas, Bull.* 3501, in press.
4. GARDNER, JULIA, The correlation of the marine Yegua of the type sections: *Jour. Paleontology*, vol. 1, pp. 245–251, 1927.
5. RENICK, B. C., and STENZEL, H. B., The lower Claiborne on the Brazos River, Texas: *Univ. Texas, Bull.* 3101, p. 98, 1931.
6. VAUGHAN, T. W., Criteria and status of correlation and classification of Tertiary deposits: *Geol. Soc. Am., Bull.*, vol. 35, p. 694, 1924.
7. OPPENHEIM, P., Über die Fossilien der Blättermergel von Theben: *K.-bayer. Akad. Wiss., Sitzungsber.*, math.-phys. Kl., vol. 32, pp. 436–438, pl. 7, figs. 1–3, 1902; Über das Alter der libyschen Stufe Zittels: *Centralbl. Min. Geol. Paleont.*, Jahrg. 1917, p. 55.
8. SCHENCK, H. G., Cephalopods of the genus *Aturia* from western North America: *Univ. California Dept. Geol. Sci., Bull.*, vol. 19, no. 19, pp. 451–452, pl. 66, fig. 4, 1931.
9. COPE, E. D., Remarks on a species of *Aturia* from the Cretaceous of New Jersey: *Acad. Nat. Sci. Philadelphia, Proc.* for 1866, no. 1, pp. 3–4, 1866.
10. CHAPMAN, F., The specific name of the Australian *Aturia* and its distribution: *Roy. Soc. Victoria, Proc.*, n. ser., vol. 34, pt. 1, pp. 12–16, 1921.
11. WHITFIELD, R. P., Gastropoda and Cephalopoda of the Raritan clays and greensand marls of New Jersey: *U. S. Geol. Survey, Mon.* 18, pp. 246–248, pl. 39, fig. 1, 1892 (as *Hercoglossa*).
12. WELLER, STUART, A report on the Cretaceous paleontology of New Jersey: *New Jersey Geol. Survey, Paleont.*, vol. 4, pp. 815–816, pl. 102, fig. 1, 1907.
13. COOKE, C. W., and STEPHENSON, L. W., The Eocene age of the supposed late Upper Cretaceous greensand marls of New Jersey: *Jour. Geol.*, vol. 36, pp. 139–148, 1928.
14. See note 7 and OPPENHEIM, P., Über *Balanophyllia ponteni*, n. sp.: *Neues Jahrb.*, Jahrg. 1917, vol. 1, pp. 5–8.
15. D'ARCHAIC, É. J., in DELANOUE, J., Note sur la constitution géologique des environs de Thèbes: *Acad. Sci. (Paris), Compt. rend.*, vol. 67, p. 714, 1868.
16. BEADNELL, H. J. L., On the Eocene and Cretaceous systems of the Nile Valley: *Geol. Soc. London, Quart. Jour.*, vol. 61, pp. 673, 676, 1905.
17. BOUSSAC, J., Observations nouvelles sur le nummulitique de la Haute-Egypte: *Soc. géol. France, Compt. rend.*, 1913, p. 63.
18. FOORD, A. H., *Catalogue of the fossil Cephalopoda in the British Museum*, pt. 2, p. 337, 1891. See also EDWARDS, F. E., A monograph of the Eocene Mollusca or description of shells from the older Tertiaries of England, pt. 1, Cephalopoda: *Paleontogr. Soc., Mon.*, pp. 51–52, pl. 9, fig. 3, 1849.
19. The siphuncular collars of the septa.
20. MORTON, S. G., *Synopsis of the organic remains of the Cretaceous group of the United States*, p. 33, pl. 18, fig. 3, 1834.
21. CONRAD, T. A., Observations on the Eocene formation: *Acad. Nat. Sci. Philadelphia, Proc.* for 1847, p. 299, 1847; *idem, Jour.*, ser. 2, vol. 1, p. 130, pl. 14, fig. 15, 1848. WHITFIELD, R. P., *U. S.*

Geol. Survey, Mon. 18, pp. 287–288, pl. 49, figs. 1, 3; pl. 50, fig. 1, 1892.

22. Von Ihering, H., Los nautilidos del tertiario patagonico y chileño: *Mus. nac. Buenos Aires, Ann.*, vol. 31, pp. 470–474, 1922.
23. See note 7.
24. Geinitz, H. B., Über *Nautilus alabamensis* Morton, *Nautilus ziczac* Sow., und *Nautilus lingulatus* Von Buch: *Neues Jahrb.*, Jahrg. 1887, vol. 2, pp. 53–56, pl. 3.
25. Whitfield, R. P., *U. S. Geol. Survey, Mon.* 18, pp. 246–248, pl. 39, fig. 1; pp. 287–288, pl. 49, figs. 1–3; pl. 50, fig. 1, 1892.
26. In Hilgard, E. W., *Report on the geology and agriculture of the State of Mississippi*, pp. 108, 121, 1860.
27. Harris, G. D., *Monograph of the marine Tertiary Mollusca of Texas* (unpublished manuscript).
28. See note 1, p. 41.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 563–571, PLS. 65–66, OCTOBER, 1935

THE NAUTILOID GENUS *ATUROIDEA* IN AMERICA

A. K. MILLER and M. L. THOMPSON
State University of Iowa, Iowa City, Iowa

ABSTRACT

The genus *Aturoidea*, of which *Paraturia* is a synonym, is intermediate between *Hercoglossa* and *Aturia*. Representatives of it are known from the Upper Cretaceous of northern Africa, the so-called Danian of India and northern Africa, and the Eocene of England, India, New Jersey, and probably Alabama and California. In this paper the genus is discussed at some length and two species, one of which is new, are illustrated and described in detail; also, a fragmentary specimen probably from Alabama is mentioned, a California species which probably represents this genus is discussed, and illustrations of the genotype are included.

In 1925 Vredenburg (1) recognized that certain Eurasian nautiloids which had been referred by some authors to *Hercoglossa* and by others to *Aturia* are generically distinct from both, and he suggested that these "may be referred to a section '*Aturoidea*' of *Nautilus*." Two years later, Spath (2), unaware of Vredenburg's "suggestion," coined the generic term *Paraturia* for congeneric forms, and he designated *Nautilus parkinsoni* Edwards as genotype Vredenburg had referred this species to *Aturoidea*, and in 1928 he and Cotter (3) suppressed *Paraturia* as a synonym of *Aturoidea*. Since then, Spath (4) also has recognized that these two terms are synonyms and that *Aturoidea* has priority. In so far as we have been able to ascertain, no genotype has ever been designated for *Aturoidea*, and, in order to stabilize the present nomenclature, we are designating *Nautilus parkinsoni* as the genotype—when *Aturoidea* was first proposed *N. parkinsoni* was listed first, presumably as "chef de file" (Pl. 66, figs. 4, 5).

In addition to the above-designated genotype, which came from the Eocene London clay of England, Vredenburg included in *Aturoidea*, *Nautilus spathi* Vredenburg of the Eocene Ranikot series of India and *N. serpentinus* Blanford of the so-called Danian "Arrialoor? group" of India. Spath has referred to *Paraturia*, *Aturia paucifex* Cope of the Eocene Hornerstown marl of New Jersey, *Nautilus schweinfurthi* Zittel of the Upper Cretaceous of northern Africa, and, questionably, *Aturia brunlechneri* Frauscher of the Eocene of Austria. Later Vredenburg and Cotter recognized that *A. paucifex* is referable to *Aturoidea*, and they also stated that Zittel and Wanner (5) had described a congeneric form from the so-called Danian of Egypt and that *Aturia mathewsonii* Gabb of the Martinez group? (Eocene) of California may represent this genus.

With the exception of *A. brunlechneri*, which probably represents *Deltoidonautilus*, all of these species that have been referred to *Aturoidea* and *Paraturia* by Vredenburg, Spath,

and Vredenburg and Cotter are closely related, and they should probably be regarded as representing one genus. However, the lateral lobes of the sutures of *N. serpentinus* and *N. schweinfurthi* are broad and differ in shape from those of the genotype of *Aturoidea*. These two species are intermediate between typical *Aturoidea* and typical *Hercoglossa*, though their subdorsal siphuncles and certain features of their sutures seem to indicate that they are more closely related to the genotype of *Aturoidea* than to that of *Hercoglossa*. The unnamed form from the Danian of Egypt that Zittel and Wanner briefly described in 1902 is stated to be similar to *N. serpentinus* and *N. delphinus* Forbes. It may represent either *Hercoglossa* or *Aturoidea*, but since it has never been illustrated or described in detail we are not able to determine its generic affinities. *N. delphinus* Forbes, from the "Danian"? of India, also may represent *Aturoidea*. Since, however, the only published illustration of the "much worn" type specimen of that species is only a diagrammatic sketch and is almost certainly erroneous in some respects, and since the only published description of it is so brief and generalized as to be of little value, the species can not be referred to any genus with a reasonable degree of certainty. The sutures of *N. forbesianus* Blanford, from the Middle Cretaceous Ootatoor group of India, are somewhat similar to those of *N. serpentinus*, but the siphuncle of *forbesianus* is subventral in position, and the species certainly is not referable to *Aturoidea*. Its umbilicus is not closed, but that presumably is not a generic character, for, as is well known, some of the living representatives of the genus *Nautilus*, s. s., have closed and others have open umbilici.

Although only six or eight species of *Aturoidea* have been described, and only one or two specimens of each of these has been found, the genus, as noted above, has a wide geographic range. In 1933 the junior author of this report studied an unlabelled, fragmentary and poorly preserved representative of this genus in the paleontological collections of the Alabama Museum of Natural History. It presumably came from the Eocene of Alabama. We are also describing below as *Aturoidea pilsbryi*, n. sp., a specimen from the Manasquan marl? of New Jersey. The stratigraphic range of the genus is very limited, and as far as is now known, it is confined to the Upper Cretaceous and the Eocene.

The Rancocas group (Hornerstown marl and Vincentown limesand) and the overlying Manasquan marl of New Jersey, which yielded the type specimens of *Aturoidea paucifex* and *A. pilsbryi*, were formerly believed to be Cretaceous. Primarily on the basis of its contained bryozoans,

---

EXPLANATION OF PLATE 65

FIGS. 1 2—*Aturoidea paucifex* (Cope); 1, lateral view (unretouched photograph), ×¾; 2, diagrammatic representation of a mature suture, ×½; holotype, Hornerstown marl near Glassboro, Gloucester County, New Jersey. (p. 567)

1

2

Miller and Thompson, Eocene Cephalopods

Clark (6) and Weller (7) concluded that the Vincentown limesand is Maestrichtian in age, and they regarded the Maestrichtian as the lower subdivision of the Danian. In 1928 Cooke and Stephenson (8) restudied the associated faunas, and they concluded that the Rancocas group and the Manasquan marl are Eocene in age and are younger than the Midway group of the Gulf Coastal Plain. Wetmore (9) has accepted Cooke and Stephenson's age-determination of these beds and has placed the bird remains found in them in families which contain species that exist today. However, Canu and Bassler (10) recently described the bryozoans of the Vincentown limesand and they state:

> The Vincentown Bryozoa certainly show close similarity to those of the Maestrichtian and Danian divisions of Europe, with various genera and some identical species, and little relationship to the usual Tertiary faunas of either Europe or America. It is true that various characteristic species of the Vincentown fauna are present in the Aquia formation in Maryland referred to the base of the Eocene and likewise that the Clayton limestone at the base of the Eocene (Midwayan) in the Gulf Coastal States contains similar genera.

It seemed to us that a restudy of the type specimens of *Aturoidea paucifex* and other representatives of the genus *Aturoidea* might yield data in regard to the age of the beds from which they came as well as to the morphology of the American species. Through the courtesy of Dr. H. A. Pilsbry of the Philadelphia Academy of Natural Sciences, we were allowed to study the holotype of *A. paucifex* and several other congeneric specimens, and we wish to take this opportunity to express our sincere appreciation for this favor. Although representatives of the genus *Aturoidea* have been found in beds which are clearly Upper Cretaceous in age, the Upper Cretaceous and the so-called Danian forms from India and northern Africa are very much more primitive than are the definitely Eocene forms, *A. parkinsoni* and *A. spathi*. As can be seen by comparing the figures on plates 65 and 66, *A. paucifex* and *A. pilsbryi* are strikingly similar to *A. parkinsoni* of the London clay (Yprésien), which has been correlated by some authors with the Aquia formation of Maryland and the upper portion of the Wilcox group of the Gulf Coastal Plain. *Aturoidea spathi* of the Eocene Ranikot series of India also appears to be very closely related, and although these four species came from three widely separated localities, the fact that they are very closely similar indicates that the beds which yielded them are probably not greatly different in age. We are somewhat uncertain in regard to the generic affinities of *Nautilus bryani* Gabb, the only other nautiloid species known from the Rancocas group—it occurs in the Vincentown limesand—but tentatively it can be placed in the genus *Eutrephoceras*, which is known to range from the Jurassic up into the lower Oligocene. This species does not seem to us to be very closely similar to any described form, and therefore at present it is of little stratigraphic significance.

The manuscript of this paper was received by the editor of the Journal March 7, 1935.

SYSTEMATIC DESCRIPTIONS

Genus ATUROIDEA Vredenburg

From a study of the two specimens available to us and the published illustrations and descriptions of the genotype and all the congeneric forms listed above, we have drawn up the following concise diagnosis of the genus *Aturoidea:*

Conch sublenticular in shape, nautiliconic in its mode of growth; all known forms large. Whorls compressed, flattened laterally, rounded ventrally, impressed dorsally. Umbilicus closed; umbilical shoulders rounded. Septa asymmetrically sigmoidal; each mature suture forms a very broad, deep, blunt ventral saddle; on either side of it a long, narrow, asymmetrical, narrowly rounded lateral lobe; a broad, deep, broadly rounded asymmetrical lateral saddle; a long, broad, rounded lobe with its center near the umbilical seam; a broad, deep, broadly rounded saddle located on the sides of the impressed zone and extending to the dorsal lobe; the dorsal lobe apparently large, more or less V-shaped but rounded. Siphuncle subdorsal in position (that is, much nearer the dorsum than the venter, but not in contact with the dorsum); orthochoanitic in structure—segments not expanded or contracted within the camerae but essentially cylindrical in shape; septal necks relatively long (only slightly shorter than the connecting rings).

Aturoidea is very closely related to *Hercoglossa* and *Aturia* and is more or less intermediate between them. It differs from *Hercoglossa* particularly in that its siphuncle is subdorsal rather than subventral in position; that the lateral lobes of its sutures are relatively long, narrow, and more narrowly rounded; and that the ventro-lateral portions of the ventral saddle of the sutures are almost subangular rather than broadly and evenly rounded. In *Aturia* the septa are typically rather close together; the sutures, though in general similar to those of *Aturoidea*, contain more nearly angular bends; and the siphuncle is dorsal in position, its segments infundibuliform. It seems probable that *Hercoglossa* arose from *Cimomia* (11) during the Cretaceous period, and that before the close of that period it gave rise to *Aturoidea;* then, during the Eocene, *Aturia* developed from *Aturoidea*, but *Cimomia*, *Hercoglossa*, and *Aturoidea* continued to exist for a time alongside of their more advanced descendants.

Ihering (12) has proposed the name *Sphenaturia* (regarded by him as a subgenus of *Aturia*) for the species of *Aturia* in which the lateral lobes of the sutures are located fairly close to the periphery of the conch, are long and narrow, and extend apicad until they are in contact, or nearly so, with the preceding sutures. Schenck (13) designated *Aturia* (*Sphenaturia*) *brüggeni* Ihering of the Tertiary of Tierra del Fuego (Chile) as the type of *Sphenaturia*. Insofar as we are able to tell from Ihering's description and illustrations, that species does not differ sufficiently from *Aturia aturi* (Basterot), the genotype of *Aturia*, to be regarded as generically or subgenerically distinct from it, and therefore we regard *Sphenaturia* as a synonym of *Aturia*.

ATUROIDEA PAUCIFEX (Cope)

Plate 65, figures 1, 2

Aturia pancifex COPE, *1866*, Acad. Nat. Sci. Philadelphia, Proc. for 1866, pp. 3–4. [Presumably "*pancifex*" was intended to read *paucifex*.]

Hercoglossa paucifex CONRAD, *1868*, in Cook, G. H., New Jersey Geol. Survey, Geology of New Jersey, p. 731.—WHITFIELD, *1892*, U. S. Geol. Survey, Mon. 18, pp. 246–248, pl. 39, fig. 1 [also issued as New Jersey Geol. Survey, Paleont., vol. 2].—JOHNSON, *1905*, Acad. Nat. Sci. Philadelphia, Proc., vol. 57, p. 28.—WELLER, *1907*, New Jersey Geol. Survey, paleont. ser., vol. 4, pp. 815–816, pl. 102, fig. 1.—GRABAU and SHIMER, *1910*, North American index fossils: Invertebrates, vol. 2, pp. 110–111, fig. 1341.

Paraturia paucifer SPATH, *1927*, India Geol.

Survey, Mem. (Palaeontologia Indica), n. s., vol. 9, no. 2, p. 26.

Aturoidea paucifex VREDENBURG and COTTER, *1928*, India Geol. Survey, Mem. (Paleontologia Indica), n. s., vol. 10, no. 4, p. 19.

"*Hercoglossa*" *paucifex* COOKE and STEPHENSON, *1928*, Jour. Geol., vol. 36, pp. 143, 144.

Conch moderately large, sublenticular in shape, nautiliconic in mode of growth. Holotype, a well preserved internal mold, septate throughout, representing only phragmacone. Its adoral camera, however, is shorter than preceding ones and therefore the specimen probably represents essentially all of the phragmacone of a mature individual. Maximum diameter, measured from adoral end of venter across umbilicus, about 200 mm.; diameter at right angles to this and across umbilicus, about 160 mm. Outer whorl flattened laterally, rounded ventrally, impressed dorsally; impressed zone about one-third as deep as conch is high. At adoral end conch 135 mm. high, 120 mm. wide (estimated); maximum width somewhat ventrad of umbilical shoulders. At adapical end of outer volution maximum height and width of conch 55 mm. and 45 mm., respectively. As indicated by these figures, conch expands orad fairly rapidly.

Umbilicus closed; in holotype attains maximum diameter of 30 mm.; umbilical shoulders very broadly rounded, more or less indistinct.

Surface of holotype, an internal mold, marked by numerous small longitudinal ridges or raised lines, discontinuous because interrupted by the broad areas of junction of the septa with the flanks of the conch. Camerae moderately long; outer volution of holotype consisting of nine camerae. Septa only slightly curved (convex apicad) in lateral direction but strongly curved dorso-ventrally; dorsal portion strongly convex orad, ventral portion strongly concave orad; septa asymmetrically sigmoidal in shape. Distance along venter between successive sutures equal to three-fifths the maximum height of the conch. On outer volution of holotype each suture forms a very broad, deep, blunt, very broadly rounded ventral saddle; and on either side a long, narrow, asymmetrical, curved, narrowly rounded lateral lobe (extension of which makes angle of 30° with venter); a broad, deep, rounded, asymmetrical, rather broadly rounded lateral saddle; a slightly narrower, long, asymmetrical, rather narrowly rounded umbilical lobe with its center just outside (ventrad of) the umbilical seam; and a deep, broad, rounded U-shaped saddle on the side of the impressed zone, extending to dorsal lobe. Precise shape of dorsal lobe not ascertainable from holotype but apparently large, more or less V-shaped but rounded.

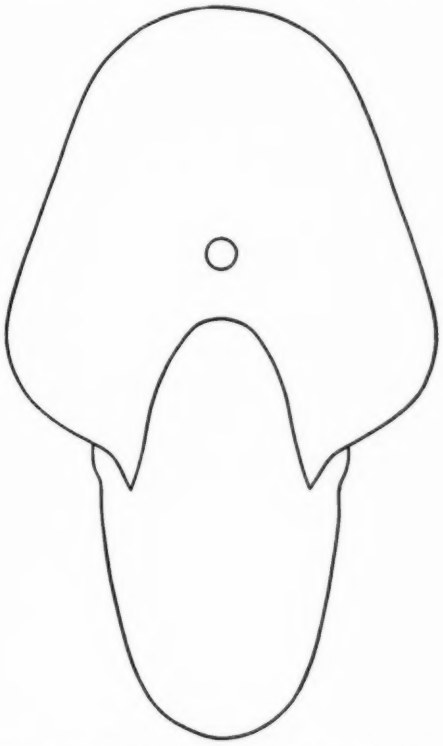


FIG. 1—*Aturoidea paucifex* (Cope), diagrammatic outline of the holotype, ×⅔.

Siphuncle moderate in size, circular in

cross section, subdorsal in position, orthochoanitic in structure; at adoral end of holotype, 10 mm. in diameter, with center 60 mm. from venter, 20 mm. from dorsum, 75 mm. from extreme dorsal portion of conch. Segments of siphuncle essentially cylindrical; septal necks long, somewhat shorter than connecting rings; at adoral end of holotype septal necks are 11 mm. long.

Remarks.—*Aturoidea paucifex* resembles rather closely *A. parkinsoni* (Edwards), *A. spathi* Vredenburg, and *A. pilsbryi* Miller and Thompson, described below, but it is not closely similar to the other known representatives of this genus, except possibly *A. mathewsonii* (Gabb). At maturity *A. parkinsoni* is much larger than *A. paucifex*, the lateral lobes of its sutures are relatively broader and more narrowly rounded, the adapical concave zone on the dorsal side of the lateral lobes is much more prominent, the conch is relatively higher and narrower, and the flanks are more evenly rounded and converge ventrad only slightly. The published illustrations of *A. spathi* are not all that could be desired, and the precise shape of the sutures cannot be determined from them, but that species appears to be very close to *A. paucifex;* however, the venter appears to be a little more narrowly rounded. The lateral lobes of the sutures of *A. pilsbryi* are shorter, broader, and more broadly rounded than are those of *A. paucifex*.

Occurrence.—The holotype of this species came from the Hornerstown marl at the "Heritages" marl pits, Glassboro, Gloucester County, New Jersey. Whitfield states that the paleontological collections of The Academy of Natural Sciences of Philadelphia contain "two chambers of the same species from Vincentown, New Jersey, collected by T. M. Bryan, Esq., which would also most probably be from the Middle Marls [Hornerstown marl], as both these and the Upper Marls [Manasquan marl] are near together at that point. Another fragment in dark brown material occurs in the tray with the fragments of *Am. telifer*, marked simply 'N.J.' "—there is now also an additional fragmentary specimen from Vincentown. We have carefully studied all of these specimens, but they are so poorly preserved and incomplete that even their generic affinities cannot be ascertained with certainty—they may represent *Aturoidea*, *Hercoblossa*, or *Cimomia*. There appears to be no good reason to believe that they are conspecific with the holotype of *A. paucifex*.

Types.—Holotype, Acad. Nat. Sci. Philadelphia 13,133. The specimens referred to this species (probably incorrectly) by Whitfield are 13,134 (Vincentown), and 13,136 ("N. J."); the other fragmentary nautiloid from Vincentown, mentioned above, is 13,135.

ATUROIDEA PILSBRYI Miller and Thompson, n. sp.

Plate 66, figures 1–3

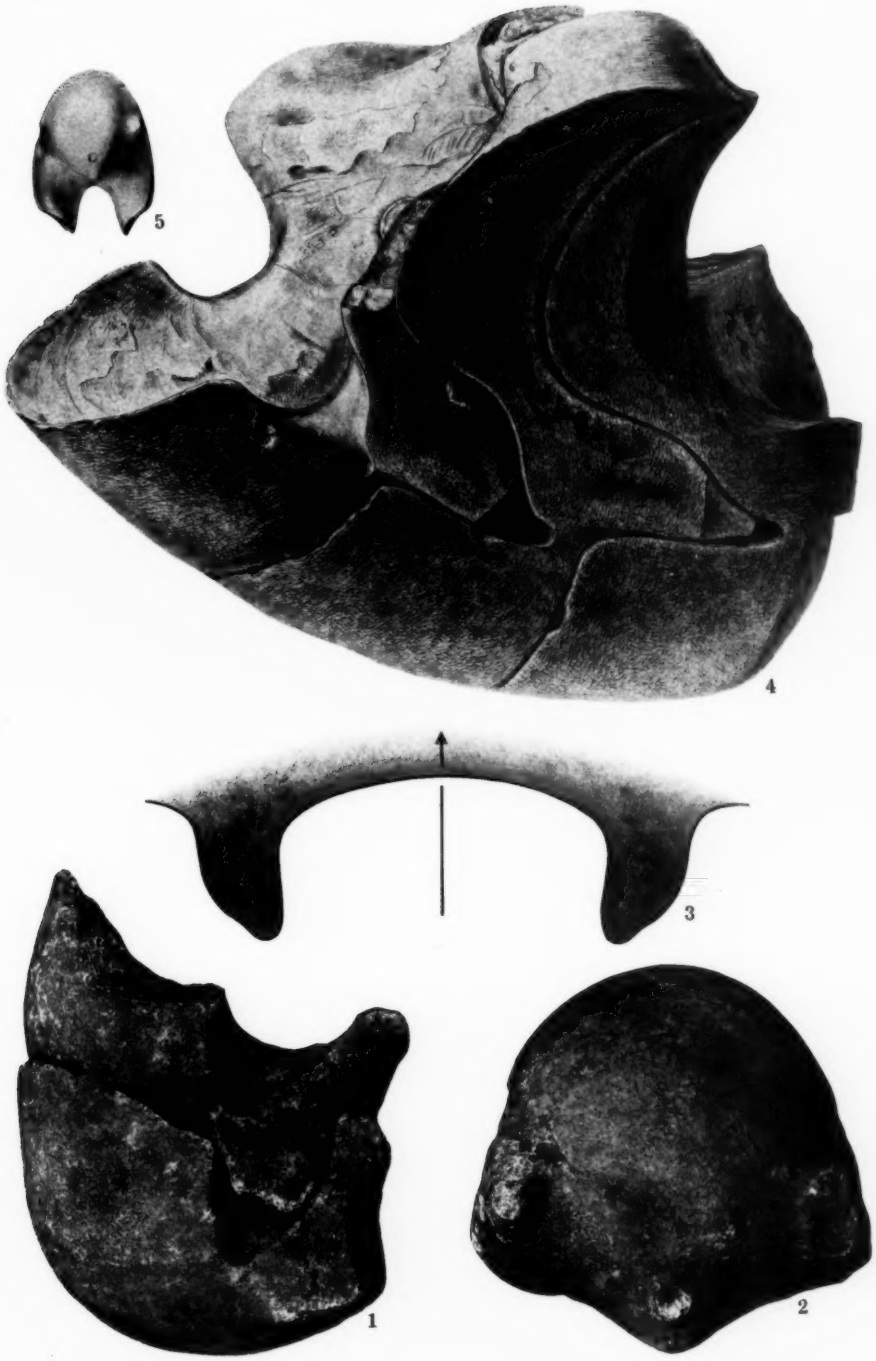
A single rather well preserved but incomplete internal mold is quite distinct from all known forms of the genus *Aturoidea*. We are describing it as the type of a new species, in spite of its incompleteness, and are naming it in honor of Dr. Henry A. Pilsbry, through whose courtesy we were permitted to study the specimens on which this paper is based.

Holotype, ventral portions of two camerae of a conch comparable in size and shape to that of *A. paucifex*. Curvature of venter indicates that phrag-

EXPLANATION OF PLATE 66

FIGS. 1–3—*Aturoidea pilsbryi* Miller and Thompson, n. sp.; 1, 2 lateral and septal (apical) views, ×¾; 3, diagrammatic representation of the preserved part of the suture, ×½; holotype, Manasquan marl? near Medford, New Jersey. (p. 569)

4, 5—*Aturoidea parkinsoni* (Edwards); lateral view, ×½, and septal (apical) view; holotype, genotype; London clay, England (After Edwards). (p. 563)



Miller and Thompson, Eocene Cephalopods

macone attained maximum diameter (measured across umbilicus) of at least 200 mm. Conch flattened laterally, rounded ventrally, impressed dorsally; cross section similar to that of *A. paucifex;* maximum width 80 mm.; at adoral end distance from venter to dorsum (bottom of impressed zone) slightly more than 70 mm.

Surface of internal mold devoid of markings other than sutures. Septa only slightly curved laterally, strongly curved dorso-ventrally; ventral portion convex apicad, dorsal portion presumably concave apicad. Length of adapical camera, measured along venter, about 40 mm. Preserved part of each suture forms large, broad, deep, broadly rounded ventral saddle; on either side of it a much narrower, narrowly rounded, long lateral lobe (dorsal side of which is sigmoidal), and a deep lateral saddle.

Siphuncle moderate in size, circular in cross section, subdorsal in position, orthochoanitic in structure; at adoral end siphuncle 7 mm. in diameter; its center 52 mm. from venter, slightly more than 15 mm. from dorsum (bottom of impressed zone).

Remarks.—A. pilsbryi resembles rather closely *A. paucifex* (Cope), *A. parkinsoni* (Edwards), and *A. spathi* Vredenburg, but it is not very close to the other known representatives of this genus, except possibly *A. mathewsonii* (Gabb). The relatively short and broad lateral lobes of its sutures distinguish this species from *A. paucifex*, *A. parkinsoni*, and *A. spathi*. Also, the siphuncle of *A. paucifex* is distinctly larger than is that of *A. pilsbryi*.

Occurrence.—The label which accompanies the holotype of this species indicates that it was collected by Dr. Thos. Wister at or near Medford, New Jersey. It is composed of hard cream-colored limestone which contains numerous scattered grains of glauconite and which weathers to a light brown color. Dr. L. W. Stephenson (14) has kindly advised us that the town of Medford is located on the Manasquan formation and the old Medford marl pits appear from the maps to have been dug in that formation. However, the belt of outcrop of the Vincentown lime sand lies just a little to the west of Medford and there is a possibility that this specimen may have come from the Vincentown. It is reasonably certain, however, that it came from one or the other of these two formations.

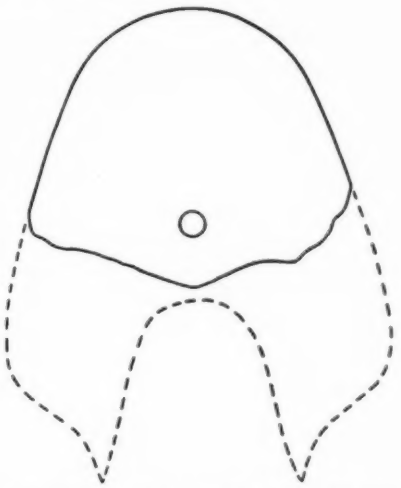


FIG. 2—*Aturoidea pilsbryi* Miller and Thompson, n. sp., diagrammatic cross section of the holotype, ×½.

Holotype.—Acad. Nat. Sci. Philadelphia 13,137.

ATUROIDEA MATHEWSONII (Gabb)

All of the available information (including a synonymy) in regard to this species has recently been published by Schenck (15). It should be noted, however, that the type specimens of this species apparently came from several horizons and localities, and it seems very doubtful that all of them were conspecific, or even congeneric. Normally our concept of the species would be based largely on the cotype which Gabb (16) figured in connection with the original description of the species, but in view of the fact that the sutures as

portrayed by Gabb's figure are so unlike those of any form known to us, we doubt that the illustration is correct in detail—the specimen on which this illustration was based has been lost and the horizon and locality from which it came are not known.

Vredenburg and Cotter (17) stated that this species should probably be referred to *Aturoidea*, but they had seen no descriptions or illustrations of it. The specimen figured by Dickerson (18) as *mathewsonii* probably represents the genus *Aturia* and apparently is not at all similar to the cotype figured by Gabb. The specimen figured and described by Schenck (19) as a lectotype of *mathewsonii* may possibly be the specimen (cotype) on which Gabb's illustration was based. Although the nature and position of its siphuncle are not known, its sutures indicate that it is referable to *Aturoidea* and is closely related to *A. parkinsoni* (Edwards), *A. spathi* Vredenburg, *A. paucifex* (Cope) and *A. pilsbryi* Miller and Thompson. The horizon and locality from which this lectotype specimen came are unknown, but its similarity to the species just listed indicated that it came from the Eocene.

Schenck (20) believed that *Aturia kerniana* Anderson and Hanna is probably a synonym of *A. mathewsonii*, but the figured type specimen of *kerniana* is very small (only about 20 mm. in diameter) and is almost certainly an immature individual. The sutures of this species as illustrated by Anderson and Hanna (21) indicate that it may be referable to *Aturoidea*, but Schenck states that their diagram is not correct, and it apparently is not based on the figured type specimen. The specimen, from the same horizon and locality as the figured type of *A. kerniana*, that Schenck (22) figured and referred to that species probably represents the genus *Aturia*.

In summary, then, we feel justified in concluding that the genus *Aturoidea* is known to be represented in the Eocene of California by at least one species, *A. mathewsonii*?.

REFERENCES

1. Vredenburg, E. W., Descriptions of Mollusca from the post-Eocene Tertiary formation of northwestern India: Cephalopoda, Opisthobranchiata, Siphonostomata: *India Geol. Survey, Mem.* (*Palaeont. Indica*), n. s., vol. 50, pt. 1, p. 9, 1925.
2. Spath, L. F., Revision of the Jurassic cephalopod fauna of Kachh (Cutch): *India Geol. Survey, Mem.*, vol. 9, no. 2, p. 22, 1927.
3. Vredenburg, E. W., edited with notes by Cotter, G. de P., A supplement to the Mollusca of the Ranikot series: *India Geol. Survey, Mem.* (*Palaeont. Indica*), n. s., vol. 10, no. 4, pp. 13–20, and corr. slip, 1928.
4. Spath, L. F., Corrections of cephalopod nomenclature: *The Naturalist*, p. 269, 1929.
5. Von Zittel, K. A., and Wanner, Johannes, Die Fauna der obersten weissen Kreide der libyschen Wüste: *Palaeontographica*, Bd. 30, pt. 2, p. 144, 1902.
6. Clark, W. B., Report upon the Upper Cretaceous formations: *New Jersey Geol. Survey, Ann. Rept.* for 1897, p. 207, 1898.
7. Weller, Stuart, A report on the Cretaceous paleontology of New Jersey: *New Jersey Geol. Survey, Paleont. ser.*, vol. 4, p. 184, 1907.
8. Cooke, C. W., and Stephenson, L. W., The Eocene age of the supposed late Upper Cretaceous greensand marls of New Jersey: *Jour. Geol.*, vol. 36, pp. 139–148, 1928.
9. Wetmore, Alexander, The age of the supposed Cretaceous birds from New Jersey: *The Auk*, vol. 47, pp. 186–188, 1930.
10. Canu, Ferdinand, and Bassler, R. S., The bryozoan fauna of the Vincentown limesand: *U. S. Nat. Mus., Bull.* 165, p. 3, 1933.
11. The oldest representative of *Cimomia* with which we are acquainted is *C. romeroi* (Ihering) (*Mus. Nac. Buenos Aires, An.*, ser. 3, tom. 2, pp. 195–196, pl. 1, fig. 1, 1903), Upper Cretaceous, Argentina.
12. Von Ihering, H., Nautílidos del terciario de Chile y de la Argentina (nota preliminar): *Physis, Soc. Argentina Cien. Nat., Revista*, tom. 5, no. 19, p. 76, 1921; Los nautílidos del terciario patagónico y chileno: *Mus. Nac. Buenos Aires, An.*, tom. 31, pp. 470–474, 1922.

13. SCHENCK, H. G., Cephalopods of the genus *Aturia* from western North America: *Univ. California Dept. Geol. Sci., Bull.*, vol. 19, no. 19, p. 450, 1931.
14. Personal communication, dated February 19, 1935.
15. *Op. cit.* in note 13, pp. 452–454, text-figs. 4(2), 4(16), pl. 66, figs. 1, 2.
16. GABB, W. M., Description of the Cretaceous fossils: *California Geol. Survey, Palaeont.*, vol. 1, pp. 59–60, pl. 17, fig. 31, 1864.
17. *Op. cit.* in note 3, p. 19.
18. DICKERSON, ERNEST, Fauna of the Martinez Eocene of California: *Univ. California Dept. Geol. Sci., Bull.*, vol. 8, no. 6, pl. 18, fig. 1, 1914.
19. *Op. cit.* in note 13, pp. 452–454, text-fig. 4(2), pl. 66, figs. 1, 2.
20. *Op. cit.* in note 13, pp. 452–453, 456–457.
21. ANDERSON, F. M., and HANNA, G. D. Fauna and stratigraphic relations of the Tejon Eocene at the type locality in Kern County, California: *California Acad. Sci., Occ. Papers*, vol. 11, text-fig. 2 (p. 49), 1925.
22. *Op. cit.* in note 13, pl. 66, fig. 3.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 572–587, PLS. 67–69, OCTOBER, 1935

MIOCENE LEAVES, FRUITS, AND SEEDS FROM IDAHO, OREGON, AND WASHINGTON

ROLAND W. BROWN
U. S. Geological Survey, Washington, D. C.

ABSTRACT

Recent collections obtained by the writer included the 22 species selected for discussion here. Some of these are new; others are described species whose identity is now rendered more certain by confirmatory materials such as leaves and seeds. Many of these species serve to emphasize the fact that there were present in some Tertiary floras of the northwestern states trees whose only surviving relatives now live in the eastern hemisphere.

When well-preserved fossil seeds or their impressions are found in association with leaves and other plant remains, and they mutually confirm one another, the paleobotanist has cause for rejoicing. Such are many of the specimens to be discussed here. They were selected from large collections made by enthusiastic local students or by the writer, who visited numerous fossil plant localities in the northwestern states during the summers of 1930, 1931, and 1934. The following is a brief summary of the essential facts about the localities yielding these fossils:

1. Republic, Washington. The fossils occur principally in the upper layers of the 60 feet, more or less, of light-colored, fine-grained, dense, tuffaceous shale exposed conspicuously in the steep hillside on the right side of the road as one comes into the town from the south. These deposits rest upon or are intercalated with andesite flows and underlie Tertiary basalt. Leaves, flowers, seeds, and insects, although relatively scarce, are well-preserved and appear black against the light-colored matrix. The writer visited this locality on August 1, 1934, with Prof. T. A. Bonser and son, of Spokane, Washington.

2. Spokane, Washington. The region in and about Spokane furnishes the type locality and many other exposures of the Latah formation, the stratigraphy, lithology, and paleontology of which have been described in Professional Papers 140 and 154 of the U. S. Geological Survey. The writer visited a number of these Latah outcrops containing fossil plants on July 31 and August 2, 1934, with T. A. Bonser, C. O. Fernquist, and E. E. Alexander—men to whom much credit is due for their assiduous and careful collecting that has resulted in increased knowledge of the Latah flora.

3. On Potlatch Creek between Arrow Junction and Juliaetta, Latah County, Idaho. From 10 to 15 feet of diatomaceous beds, between basalt flows and correlated with the Latah formation, are exposed in the hillside along the left side of the road up Potlatch Creek from Arrow Junction to Juliaetta. These beds are as fossiliferous as those in the type region of the Latah formation at Spokane and preserve many of the same species. They were examined on August 6 and 7, 1934, by the writer, with John C. Reed, of the U. S. Geological Survey, and Donald W. McGlashan, of Twin Falls, Idaho.

4. White Bird, Idaho. On the left side of the road 2.5 miles east of White Bird toward Grangeville, Idaho, is an outcrop of reddish-brown shale dipping 28° north. Its stratigraphic relations are not clear because it occurs in open foothill and valley country that

shows considerable evidence of land-slipping and faulting. The surrounding mountains disclose exposures of Columbia River basalt and intercalated beds of light-colored sediments. This locality was examined August 12, 1934, with John C. Reed and Donald W. McGlashan.

5. Salmon, Idaho. In the steep banks on both sides of the Salmon River at Salmon, Idaho, and on hillside escarpments farther back in the valley occur outcrops of lake beds composed of sandstones, shales, and occasional lignite seams. The most productive fossil locality was the G. W. Oliver coal mine, on Jesse Creek about 3 miles west of Salmon. At that place reddish-brown, thinly laminated, soft shale is associated with the coal and yields ferns, dicotyledonous leaves, insects (grasshoppers and beetles), and fragmentary fishes. Collections were made (*a*) near the home of Mr. Philip Rand on the left bank of Salmon River; (*b*) near the electric power house on the right bank of the Salmon River; and (*c*) at the G. W. Oliver coal mine. The writer visited these localities with C. P. Ross, of the U. S. Geological Survey, early in July, 1930. Ross includes the sediments with the Challis volcanics.

This paper is published with the permission of the Director of the U. S. Geological Survey. The manuscript was received by the editor of the Journal April 25, 1935.

SYSTEMATIC DESCRIPTIONS

PINACEAE

SEQUOIA LANGSDORFII (Brongniart) Heer

Plate 67, figures 1, 2, 10

Sequoia langsdorfii (Brongniart) HEER [seeds], *1868*, Flora fossilis artica, vol. 1, p. 91, pl. 2, figs. 6, 7; pl. 21, fig. 7; pl. 45, fig. 16. See KNOWLTON, *1919*, Catalogue of Mesozoic and Cenozoic plants of North America, U. S. Geol. Survey, Bull. 696, p. 594, for further references on leaves, etc.

The two fossil seeds figured here (figs. 1, 2) may be compared satisfactorily with the seeds of either the redwood, *S. sempervirens* Endlicher (fig. 3), or the big tree, *S. gigantea* Decaisne (fig. 4). Since there is little or no perceptible outward distinction between the living seeds of these two species, and since there would likely be even less in fossil material, it seems most probable that, because the twigs of *Sequoia* found in the same deposits as the seeds are of the redwood kind, identified as *Sequoia langsdorfii*, the seeds also belong to this species. Similar seeds and twigs occur with cones in the lower part (Bridge Creek shale of authors) of the John Day formation in the Crooked River and John Day Basins of Oregon.

A cone (fig. 10), similar to a small redwood cone, found with the foliage of *S. langsdorfii*, attests the presence of *Sequoia* in eastern Idaho in Miocene time. This cone may be contrasted with a portion of a bald cypress cone (fig. 9), *Taxodium dubium* (Sternberg) Heer, of which a more complete specimen has been figured recently by Berry (1) from White Bird, Idaho. These and other remains such as twigs and wood from numerous widely separated localities show definitely that both *Sequoia* and *Taxodium* existed simultaneously in ecologic association or separately in the northwestern states during a portion or perhaps all of Miocene time.

Occurrence.—Loc. 1 (figs. 1, 2); loc. 3 (fig. 9); loc. 5*b* (fig. 10). Figured specimens in U. S. Nat. Mus.

KETELEERIA HETEROPHYLLOIDES (Berry) Brown, n. comb.

Plate 67, figures 23–25

Grass, leaf of, KNOWLTON, *1926*, U. S. Geol. Survey, Prof. Paper 140, p. 29, pl. 10, fig. 7.

Potamogeton heterophylloides BERRY, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 240, pl. 50, figs. 1–3. [Not *Potamogeton* sp., Knowlton, *1926*, U. S. Geol. Survey, Prof. Paper 140, p. 29, pl. 10, figs. 5, 6].

The large amount of carbon left in many of these fossil impressions indicates that the original leaves were relatively

thick. This fact together with the distinctive curvature and the lack of venation, suggests coniferous rather than monocotyledonous foliage. Knowlton's figure of the grass leaf is somewhat misleading in that the central furrow appears to be deep, the apex blunt, and the margins much rounded—characters that might readily enough be matched in the "double needles" of *Sciadopitys verticillata* Siebold and Zuccarini, the handsome umbrella pine of southern Japan. However, inspection of the specimen itself shows that it is a linear, oblanceolate needle with a comparatively shallow furrow, a blunt-pointed apex (after removal of encrusting matrix), a flat surface composed of two broad bands of many parallel, longitudinal stomatal lines, and only slightly revolute margins. All the specimens, when cleaned, exhibit these characters.

The fact that these impressions are pointed, not emarginate, and that a furrow appears where a ridge should be, eliminates them from *Sciadopitys*. The two broad bands of stomatal lines, and the gradually tapering base, eliminate them from *Torreya*, which has two narrow stomatal grooves and an abruptly cuneate base. The needles of *Cephalotaxus* differ from the fossils in being prominently sharp-pointed and lanceolate. This leaves the fossils to resemble most closely the needles of *Keteleeria davidiana* Beissner, one of two or three species of tall fir-like trees in China.

Records of fossil *Keteleeria* are few. A cone, originally called *Abies loehri* by Geyler and Kinkelin, but later identified as *Keteleeria loehri* by Engelhardt and Kinkelin, was found in Pliocene beds of Germany. Wood, identified by I. W. Bailey as probably *Keteleeria*, was found in the McMurray formation (Lower Cretaceous) in Alberta, Canada (2).

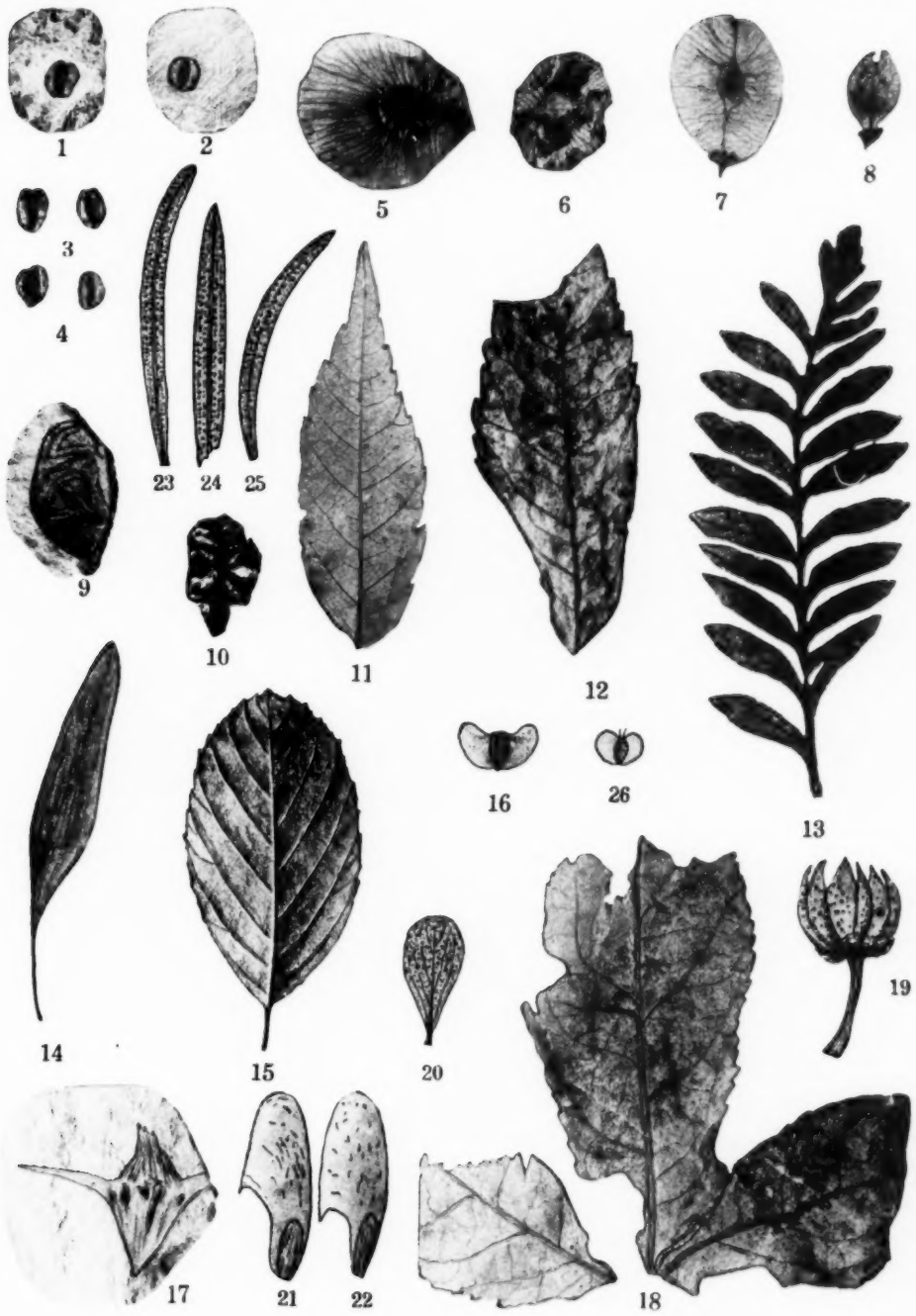
The thin fragmentary specimen called *Potamogeton* sp. by Knowlton and synonymized with *P. heterophylloides* by Berry, may be a *Potamogeton*. However, the parallel lines shown on Knowlton's figure 6, the enlargement of figure 5, and suggesting a grass leaf, are not present in the specimen. Instead there are irregular longitudinal veins, one near the margin on each side of the blade, with a lattice-work of connecting veinlets, as in some species of *Potamogeton*.

Occurrence.—Loc. 2. Figured specimens in U. S. Nat. Mus.

EXPLANATION OF PLATE 67

All figures natural size

FIGS. 1, 2—Seeds, *Sequoia langsdorfii* (Brongniart) Heer. Republic, Wash. (p. 573)
3—Seeds, *Sequoia sempervirens* Endlicher, Living. (p. 573)
4—Seeds, *Sequoia gigantea* Decaisne. Living. (p. 573)
5, 11—Seed and leaf, *Dipteronia sinensis* Oliver. Living. (p. 580)
6, 12—Seed and leaf, *Dipteronia americana* Brown, n. sp. Republic, Wash. (p. 580)
7, 8—Seeds, *Ulmus* sp. Living. (p. 580)
9—Cone, *Taxodium dubium* (Sternberg) Heer. Potlatch Creek, Idaho. (p. 573)
10—Cone, *Sequoia langsdorfii* (Brongniart) Heer. Salmon, Idaho. (p. 573)
13—*Potentilla salmonensis* Brown, n. sp. Salmon, Idaho. (p. 579)
14, 18—Seed and leaf, *Fraxinus idahoensis* Brown. n. sp. Potlatch Creek, Idaho. (p. 583)
15—*Alnus corrallina* Lesquereux. Salmon, Idaho. (p. 575)
16—*Callitris potlatchensis* Brown, n. sp. Potlatch Creek, Idaho. (p. 575)
17—Seed, *Trapa americana* Knowlton. Potlatch Creek, Idaho. (p. 581)
19—Fruit, *Carpolithus hibiscoides* Brown, n. sp. White Bird, Idaho. (p. 584)
20—*Arctostaphylos cuneata* Brown, n. sp. Salmon, Idaho. (p. 583)
21—Seed, *Cedrela pteraformis* (Berry) Brown, n. comb. Spokane, Wash. (p. 579)
22—Seed, *Cedrela mexicana* Roemer. Living. (p. 579)
23–25—Needles, *Keteleeria heterophylloides* (Berry) Brown, n. comb. Spokane, Wash. (p. 573)
26—Seed, *Betula* sp. Spokane, Wash. (p. 575)



Brown, Miocene Plants

CALLITRIS POTLATCHENSIS Brown, n. sp.

Plate 67, figure 16

A two-winged seed, the whole having the appearance of a thumb-nut, 1 cm. across the wings; seed cuneate, showing scar of attachment at one end, and irregular longitudinal striae or wrinkles; wings thin.

Remarks.—In some respects this seed resembles those of *Betula*, and especially the fossil seeds of *Betula* (fig. 26) described by Berry (3) from the Latah formation at Spokane, Wash., but it is more than twice the normal size of *Betula* seeds, its wing-lobes project upward and outward, and it lacks the two styles that are seldom absent from fossil seeds of *Betula*. The seed compares best with those of the conifer genus *Callitris*, and particularly well with those of *C. quadrivalvis* Ventenant, the sandarach tree of the Atlas Mountains in northwestern Africa. Similar fossil seeds, together with cones and twigs, called *C. brongniarti* Endlicher, were found in the Eocene of Aix in southeastern France (4), and another species, called *C. heeri* Saporta (5), was found in somewhat later deposits at Saint-Zacharie, in the same region. The new species, *C. potlatchensis*, appears to differ from the preceding in having a wider, more open space between the forward-projecting lobes of the wings. No foliage has yet appeared to corroborate the present identification. That called *Callitris?* by Fontaine from the Lower Cretaceous of Virginia, must be regarded as doubtful.

The genus *Callitris*, allied to *Widdringtonia* and *Thuja*, includes about 15 species distributed in northwestern Africa, Madagascar, Australia, and New Caledonia.

Occurrence.—Loc. 3. Type in U. S. Nat. Mus.

BETULACEAE

ALNUS CORALLINA Lesquereux

Plate 67, figure 15

Alnus corallina LESQUEREUX, *1883*, U. S. Geol. Survey Terr., Rept., vol. 8, p. 243, pl. 51, figs. 1–3.

Alnus hollandiana JENNINGS, *1920*, Carnegie Mus. (Pittsburgh), Mem., vol. 8, no. 2, p. 413, pl. 25, fig. 3; pl. 24, fig. 8; pl. 28, fig. 1; pl. 30, figs. 1, 1*a*, 3.

Alnus microdontoides JENNINGS, idem, p. 415, pl. 24, fig. 7; pl. 30, figs. 2, 2*a*.

Since the two species of alder described by Jennings from lake beds at Missoula, Montana, appear to the writer to be variable leaves of the same species and cannot be distinguished from *Alnus corallina* Lesquereux from Corrall Hollow, California, and since the similar specimen figured here is from the lake beds of about the same age at Salmon, Idaho, only 100 miles distant from Missoula, it seems reasonable that all represent a single species. The living white alder, *A. rhombifolia* Nuttall, ranging from northern Idaho westward to the Cascade Mountains and southward through the Coast Ranges and western slopes of the Sierra Nevada, and the smooth alder, *A. rugosa* Sprengel, of eastern North America, appear to be the species whose leaves these fossils most closely resemble.

Occurrence.—Loc. 5*a*. Figured specimen in U. S. Nat. Mus.

TROCHODENDRACEAE

CERCIDIPHYLLUM CRENATUM (Unger) Brown, n. comb.

Plate 68, figures 1, 6, 8–10

Grewia crenata (Unger) HEER, *1859*, Flora Tertiaria Helvetiae, vol. 3, p. 42, pl. 109, figs. 12*a–c*; pl. 110, figs. 1–11.—*1877*, Flora fossilis arctica, vol. 4, p. 84, pl. 19, figs. 12*a*–14.—NEWBERRY, *1898*, U. S. Geol. Survey, Mon. 35, p. 120, pl. 46, fig. 2; pl. 48, figs. 2, 3.—CHANEY, *1927*, Carnegie Inst. Washington, Pub. 346, p. 133.

Grewia crenulata HEER, *1877*, Flora fossilis arctica, vol. 4, p. 85, pl. 16, fig. 96; pl. 19, figs. 16, 17.

Grewia obovata HEER, idem, p. 86, pl. 19, fig. 15.

Grewia auriculata LESQUEREUX, *1883*, U. S. Geol. Survey Terr., Rept., vol. 8, p. 252, pl. 55, fig. 1.—KNOWLTON, *1902*, U. S. Geol. Survey, Bull. 204, p. 81.

Cassia sp.?, NEWBERRY, *1898*, U. S. Geol. Survey, Mon. 35, p. 113, pl. 46, fig. 10.

The discovery of seeds (fig. 6*a*) in association with leaves (figs. 1, 6) in de-

posits at Republic, Washington, and of capsules (fig. 8) and leaves (figs. 9, 10) in the lower part (Bridge Creek shale of authors) of the John Day formation, Oregon, which are similar to those several organs in *Cercidiphyllum japonicum* Siebold and Zuccarini, the largest dicotyledonous tree of eastern Asia, makes me confidently refer all these fossil specimens to *Cercidiphyllum*. Originally the leaves were referred to *Grewia*, but a comparison of both the fossil (figs. 1, 6, 9, 10) and living leaves (figs. 2, 3, 13) with a leaf of the most nearly comparable *Grewia*, namely, *G. parviflora* Bunge (fig. 14) from Hupeh Province, China, reveals definite distinguishing differences. Although the venation in both is palmate, that in *Cercidiphyllum* has a midrib flanked normally by three well-developed pairs of lateral primaries, whereas *Grewia* has only two; in *Cercidiphyllum* the lateral and secondary veins form conspicuous loops, but in *Grewia* they suggest straightness and enter marginal teeth, which are serrate rather than crenate and gland-tipped, as in *Cercidiphyllum*.

Leaves of *Populus tremuloides* Michaux (figs. 11, 12) resemble those of *Cercidiphyllum* in many respects but differ notably as follows: 1. The venation is essentially pinnate, as in figure 12, although the tendency to palmateness is sometimes pronounced, as in figure 11; but when this is the case the first strong secondary vein, almost without exception, branches from the midrib well below the middle of the blade, whereas in *Cercidiphyllum* that first secondary departs from the midrib above the middle of the blade. 2. *Populus* leaves with palmate venation have normally only two pairs of primary lateral veins but occasionally in more cordate specimens one additional very subordinate pair. Other genera having leaves somewhat similar to *Cercidiphyllum* are: *Cercis*, *Tetracentron*, *Disanthus*, and *Ceanothus*, but space does not now permit a statement demonstrating their significant differences from *Cercidiphyllum*.

The propriety of assigning all the fossil species cited in the synonymy to *C. crenatum* may be questioned, because they appear to differ greatly among themselves in size, shape, venation, and also in geographic origin. These differences, however, can be reconciled after consideration of figures 2, 3, and 13, which represent the variable leaves from a young tree of *C. japonicum* growing on the grounds of the National Academy of Sciences, Washington, D. C. The leaf shown in figure 2 is about average in size and shape; but a few leaves from the same tree are 10 cm. in diameter, with bases quite as auriculate as that in *Grewia auriculata* Lesquereux; and some leaves match *G. obovata* exactly. The fossil leaves seem to differ from the living in being slightly asymmetric, but many living leaves also display this character.

What are the plausible ancestors of *C. crenatum*? Nearly all paleobotanists dealing with Cretaceous and Early Tertiary plants in the northern hemisphere have encountered that complex array of forms commonly assigned to *Populus*. To bring many of these doubtful *Populus*

EXPLANATION OF PLATE 68

All figures natural size

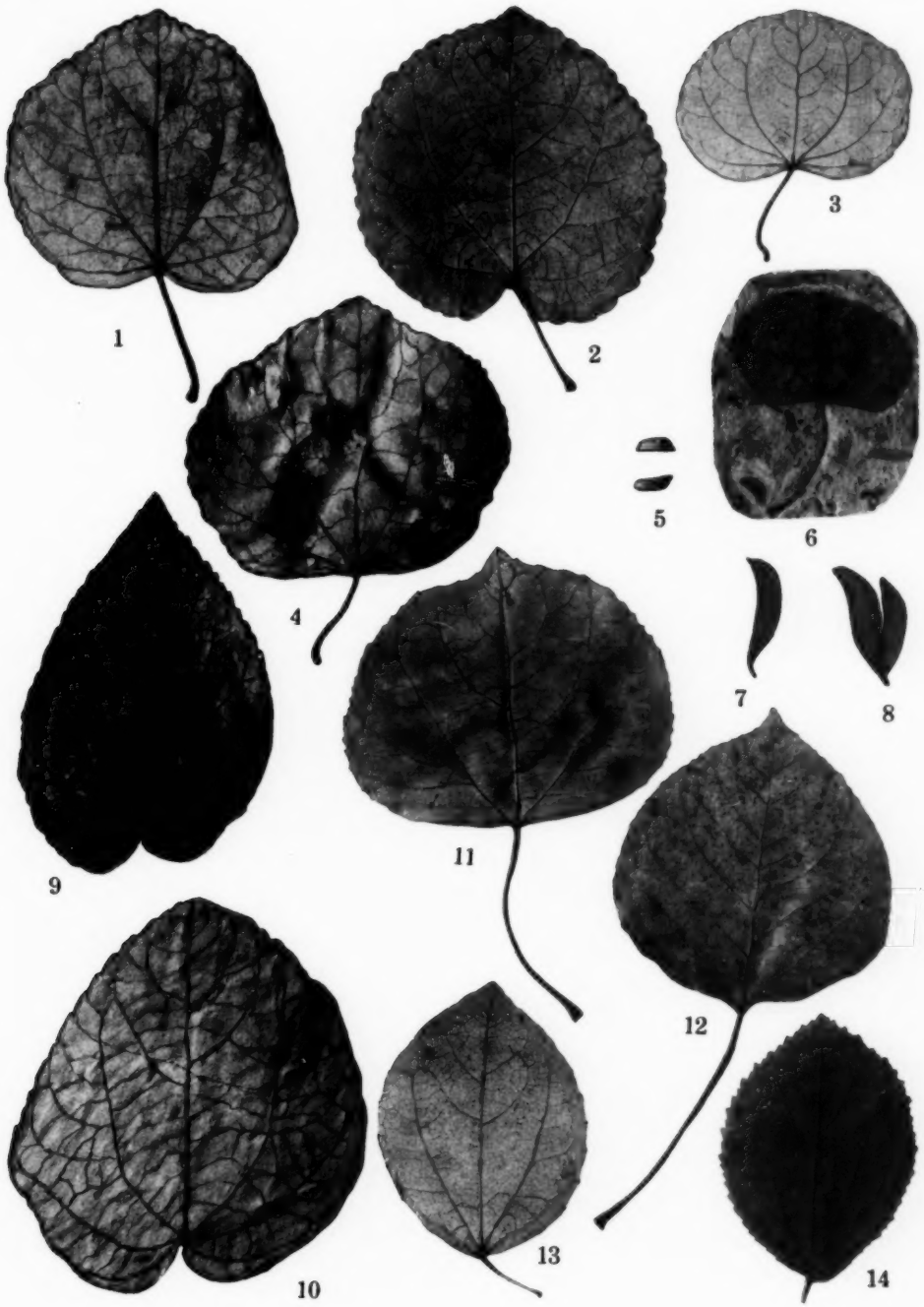
FIGS. 1, 6, 8–10—*Cercidiphyllum crenatum* (Unger) Brown, n. comb. 1, 6, 9, 10, Leaves; 6*a*, seed; 8, fruit capsule, Republic, Wash. (figs. 1, 6, 6*a*); Bridge Creek, Oreg. (figs. 8–10.) (p. 575)

2, 3, 5, 7, 13—*Cercidiphyllum japonicum* Siebold and Zuccarini. 2, 3, 13, Leaves; 5, seeds; 7, fruit capsule. Living. (p. 575)

4—*Trochodendroides genetrix* (Newberry) Brown, n. comb. Fort Union formation, Burns Ranch, Mont. (p. 577)

11, 12—*Populus tremuloides* Michaux. Living. (p. 576)

14—*Grewia parviflora* Bunge. Living. (p. 576)



Brown, Miocene Plants

forms into what seemed to be a more appropriate biologic category Berry (6) proposed the genus *Trochodendroides*. In 1926 and 1930 Berry (7) further elaborated the genus by making the following new combinations: *Trochodendroides arctica* (Heer) Berry, *T. speciosa* (Ward) Berry, and *T. cuneata* (Newberry) Berry, which were intended to embrace a number of the 25 species of *Populus* ascribed to the Fort Union flora. A suggested confirmation that these leaves were from primitive angiospermous trees of trochodendraceous or magnoliaceous affinity is given by Mathiesen (8), who reports from Eocene deposits of Greenland a fossil wood, called by him *Tetracentronites hartzi*, and leaves (p. 59, text-fig. 25) of that ubiquitous Early Tertiary form, *Populus arctica* Heer. It seems probable, therefore, that some such Eocene species as that shown in figure 4, identified by Ward as *Populus glandulifera* Heer (9), from beds of Fort Union age at Burns Ranch, 30 miles northeast of Glendive, Montana; or *Populus genetrix* Newberry (10), from an unrecorded point on the Yellowstone River; or *Grewia crenata* (Unger) Heer (11), from Eocene beds in the Bull Mountains of Montana, may have been in the trochodendraceous line giving rise to *Cercidiphyllum crenatum*. Because the specimens identified by Ward as *Populus glandulifera* and *Grewia crenata* differ distinctly from the types after which they were named but agree in all essential respects with Newberry's *Populus genetrix*, and because all these species illustrate trochodendroid characters, they may now be designated as *Trochodendroides genetrix* (Newberry) Brown, n. comb.

An extensive review of the fossil forms that might be confused with *C. crenatum* cannot be given here. In general, however, any relatively contemporaneous fossil leaf having the same appearance as *C. crenatum* but with dominantly five-palmate venation and sharper, serrate to dentate, marginal teeth should be suspected of being specifically, if not generically, different. For example, the specimens of *Populus zaddachi* Heer reported by Lesquereux (12) from the auriferous gravels of California and by Jennings (13) from lake beds at Missoula, Montana, suggest rhamnaceous rather than trochodendraceous affinities.

Cercidiphyllum is an opposite-leaved genus of one species, *C. japonicum* Siebold and Zuccarini, in Japan, and a variety, *sinense* Rehder and Wilson, in western China.

Occurrence.—Loc. 1 (figs. 1, 6); lower part (Bridge Creek shale of authors) of John Day formation, John Day Basin, Oregon (figs. 8–10). All figured specimens in U. S. Nat. Mus., except figure 9, which is in Peabody Museum, Yale University.

MAGNOLIACEAE

LIRIODENDRON HESPERIA Berry

Plate 69, figures 14, 15

Liriodendron hesperia BERRY, *1929*, U S. Geol. Survey, Prof. Paper 154, p. 249, pl. 51, figs. 2, 3.

The leaf and seed figured here came from the same locality in the Latah formation at Spokane, Washington, that supplied the seeds described by Berry. The leaf is apparently a small specimen of the species and differs slightly in venation from a normal large leaf of the tulip tree, *Liriodendron tulipifera* Linnaeus. This species may be the same as *L. trilobata* Chaney (14), but the extremely fragmentary nature of that specimen raises some doubts as to its identity. Endo (15) has recently reported *L. honsyensis* [probably a misspelling for *honshuensis*] from Japan. It is little different from *L. tulipifera*.

Occurrence.—Loc. 2. Figured specimens in U. S. Nat. Mus.

ROSACEAE

AMELANCHIER DIGNATUS (Knowlton) Brown, n. comb.

Plate 69, figures 5, 6

Celastrus dignatus KNOWLTON, *1902*, U. S. Geol. Survey, Bull. 204, p. 71, pl. 9, fig. 5.

Amelanchier peritula COCKERELL, *1908*, Am. Mus. Nat. Hist., Bull. 24, art. 17, p. 95, pl. 6, fig. 6.
Amelanchier scudderi COCKERELL, 1906, Torrey Bot. Club, Bull., vol. 33, p. 310, text fig. 4.—BERRY, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 252, pl. 55, fig. 4.—BERRY, *1934*, U. S. Geol. Survey, Prof. Paper 185, p. 113.
Amelanchier grayi CHANEY, *1927*, Carnegie Inst. Washington, Pub. 346, p. 120, pl. 14, figs. 3–5.—MACGINITIE, *1933*, Carnegie Inst. Washington, Pub. 416, p. 58.
Phyllites couleeanus BERRY, *1931*, U. S. Geol. Survey, Prof. Paper 170, p. 42, pl. 13, fig. 12.

It is possible to duplicate all the species listed in the synonymy with leaves from *Amelanchier alnifolia* Nuttall, of the western United States, and the fossils are therefore considered to represent a single species. The argument based on width of blade and number of teeth, used by Cockerell, 1908, for distinguishing *A. peritula* from *A. scudderi* is plausible for those two specimens but cannot be maintained in the presence of abundant fossil and living material.

Occurrence.—Loc. 5*a* (fig. 6); loc. 5*c* (fig. 5). Figured specimens in U. S. Nat. Mus.

CHAMAEBATIA PREFOLIOLOSA Brown, n. sp.

Plate 69, figure 4

This fernlike specimen is a tripinnatifid leaf, with minute, bluntly pointed or rounded ultimate divisions; leafy appendages distributed along the rachis; venation not discernible.

Remarks.—In every respect this specimen is so similar to a leaf of "mountain misery," *Chamaebatia foliolosa* Bentham, that a different name is given with considerable reluctance. That species must not be confused with *Chamaebatiaria millefolium* (Torrey) Maximowicz, which has twice-pinnate leaves. As a clue to the nature and habitat of the fossil, Muir's statement concerning *C. foliolosa* in the Yosemite National Park may be quoted (16):

> As soon as you enter the pine woods you meet the charming little *Chamaebatia foliolosa*, one of the handsomest of the Park shrubs, next in fineness and beauty to the heathworts of the Alpine regions. Like adenostoma it belongs to the rose family, is from twelve to eighteen inches high, has brown bark, slender branches, white flowers like those of the strawberry, and thrice-pinnate glandular, yellow-green leaves, finely cut and fernlike, as if unusual pains had been taken in fashioning them. Where there is plenty of sunshine at an elevation of three thousand to six thousand feet, it makes a close, continuous growth, leaf touching leaf over hundreds of acres, spreading a handsome mantle beneath the yellow and sugar pines.

This appears to be the first fossil record of *Chamaebatia*.

Occurrence.—Loc. 5*c*. Type in U. S. Nat. Mus.

MALUS IDAHOENSIS Brown, n. sp.

Plate 69, figure 12

Leaf broadly ovate, 7.5 cm. long, 6 cm. wide, with blunt-pointed apex, coarsely crenate-serrate margin, broad rounded base, and a petiole 2 cm. or more long. Midrib heavy and irregular; secondaries few, widely spaced, emerging from the midrib at angles of 60° to 70°, curving upward gradually to within a few millimeters of the margin, then looping abruptly to the secondaries above; tertiary venation in lower central portion of the blade nearly horizontal, but becoming more diagonal in the upper and outer areas. Neither the base of the blade nor the upper part of the petiole definitely show the presence of glands that generally occur on *Prunus* leaves, which this leaf somewhat resembles, in particular, those of the Pacific plum, *P. subcordata* Bentham.

Remarks.—This leaf may be compared favorably with those of a number of apples (*Malus*), but particularly *M. prunifolia* Willdenow or its varieties, of eastern Asia. Among fossils it is like the broken leaves from the Mascall formation called *Celastrus confluens* Knowlton (17), but these, when better material is discovered, may prove to be *Prunus*. At

least they do not, in the writer's opinion, qualify as *Celastrus*.

Occurrence.—Loc. 5*c*. Type in U. S. Nat. Mus.

POTENTILLA SALMONENSIS Brown, n. sp.
Plate 67, figure 13

Leaf pinnately compound or divided; leaflets average 1.5 cm. in length, lanceolate in outline, entire or sparsely serrate toward the rounded apex, and attached to the rachis by decurrent bases, giving the rachis an alate appearance. Terminal leaflet broader than the rest, cuneate in form, with small rounded lobes. Venation visible only in a few small areas, pinnate, with a fine network of anastomosing connecting veinlets.

Remarks.—The general characters of this leaf suggest its rosaceous affinity. It, however, does not appear to be comparable to any living *Geum*, *Sorbus*, or *Crataegus*, but rather seems to be allied to *Potentilla*, with considerable likeness to *P.* (*Horkelia*) *parryi* Greene, of California, and *P. chinensis* Seringe, of eastern Asia, although the latter species has a somewhat different venation.

Occurrence.—Loc. 5*c*. Type in U. S. Nat. Mus.

MELIACEAE

CEDRELA PTERAFORMIS (Berry) Brown, n. comb.
Plate 67, figure 21

Acer sp.?, NEWBERRY, *1898*, U. S. Geol. Survey, Mon. 35, p. 115, pl. 46, fig. 8.
Carpolithus pteraformis BERRY, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 264, fig. 5.
Gordonia pteraformis BERRY, *1929*, Am. Jour. Sci., vol. 18, p. 431.

This distinctive winged seed illustrates a feature not shown in either of the previously figured specimens, namely, a spiny extension of the lower wing-margin. With the discovery of a seed having this character it is now possible to distinguish these seeds from those of *Acer*, *Gordonia*, *Pinus*, and others, and to identify them confidently as those of *Cedrela*. Compared with the seeds of American species of *Cedrela*, especially *C. mexicana* Roemer (fig. 22), of Mexico and the West Indies, they present only slight differences, but agree in all essential particulars. Not all the seeds of *Cedrela*, however, possess the marginal spine, but many resemble the two previously figured fossil seeds in having a rounded margin without a spine.

The seeds of *Cedrela* are borne in large, thick-walled, five-valved, oblong or obovate capsules, dehiscent at maturity. These capsules should serve as excellent fossilizable material if opportunity afforded. One such object from the Latah formation at Spokane was described by Knowlton as *Carpites paulownia* (18). That capsule appears to rest upon the expanded apex of the peduncle; but those flanges may be the stubs of valves or remnants of the calyx, and what seems to be the capsule proper may be only the impression of two valves not yet separated from the unit. In size, shape, and structure this object compares much more favorably with the capsules of *Cedrela* than with those of *Paulownia*.

It is possible that certain fossil leaves from the same locality may be correlated with the species that produced the capsule and the *Cedrela* seeds. Such leaves are the specimen called *Umbellularia dayana* (Knowlton) Berry (19), and that called *Sapindus armstrongi* Berry (20). For lack of more confirmatory material, however, it seems best not to synonymize the capsule and leaves with *C. pteraformis* at this time.

Cedrela is a genus of nine species in tropical and subtropical America, and eight species (sometimes called *Toona*) in southeastern Asia and Australia. Of these species, *C. sinensis* Jussieu, of China, is hardy as far north as Massachusetts; the others only in southern California and the Gulf States. *C. odorata* Linnaeus, the West Indian cedar, supplies the fragrant, reddish-brown wood used in the manufacture of cigar boxes.

Occurrence.—Loc. 2. Figured specimen in U. S. Nat. Mus.

ACERACEAE

ACER NEGUNDOIDES MacGinitie

Plate 69, figures 9–11

Acer, fruits of, LESQUEREUX, *1888*, U. S. Nat. Mus., Proc., vol. 11, p. 15, pl. 7, fig. 2 [not pl. 6, figs. 2, 3].

Acer minor KNOWLTON, *1902*, U. S. Geol. Survey, Bull. 204, p. 76, pl. 14, fig. 3 [not fig. 2].

Acer osmonti Knowlton, CHANEY, *1927*, Carnegie Inst. Washington, Pub. 346, p. 126, pl. 18, fig. 7 [not figs. 8, 9].

Acer oregonianum Knowlton, BERRY, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 255, pl. 57, fig. 2; pl. 63, fig. 11.

Acer negundoides MACGINITIE, *1933*, Carnegie Inst. Washington, Pub. 416, p. 62, pl. 11, figs. 2, 3.

The distinguishing features of these samaras are the extremely elongated seeds, the almost uniform 45° angle of the line of separation, and the prominent upturned nose on the upper end of that line. Figure 11 represents an unusually large specimen. It is not surprising that a box elder should be found in the Miocene floras of the northwestern states, for *Acer negundo* Linnaeus and its varieties today have a distribution along streams from the eastern United States to Utah, New Mexico, Arizona, and California. Corresponding forms occur in China and Japan.

Fossil leaflets that may belong to this species are not lacking in the collections, but it is difficult to separate them from other species of *Acer*. Wanted: a compound leaf that will definitely confirm the present identification.

Occurrence.—Loc. 2 (fig. 11); lower part (Bridge Creek shale of authors) of the John Day formation, Oregon (figs. 9, 10); Mascall formation, John Day Basin, Oregon; and Loc. 1 (none figured). Figured specimens in U. S. Nat. Mus.

DIPTERONIA AMERICANA Brown, n.sp.

Plate 67, figures 6, 12

Comptonia insignis (Lesquereux) Cockerell, BERRY, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 241, pl. 50, fig. 5.

Winged samara (fig. 6), rounded, with truncate base, 1.5 cm. in diameter. The seed occupies the central portion and is connected to the truncate base by a narrow band of thick tissue. Fairly straight, but sometimes forked, veins run to the perimeter of the wing. Leaflet (fig. 12), lanceolate in outline, asymmetric; main secondaries leave the midrib at a wide angle, sometimes fork near the margin, and enter the large rounded-serrate teeth; intermediate secondaries common; nature of tip unknown.

Remarks.—This fossil seed resembles closely the samaras of *Dipteronia sinensis* Oliver (fig. 5), a small compound-leaved tree from central and western China, whose fruits, like those of *Acer*, grow in twins, the truncate base being the line of separation at maturity. In size they vary considerably, sometimes attaining a diameter of 5 cm. Winged seeds of *Ulmus* (figs. 7, 8) with which the fossil might be confused, differ by having a cuneate base, more anastomosing netted venation, and bilateral symmetry. Similar comparisons also eliminate the apparently comparable seeds of *Ptelea*, *Dodonaea*, and *Paliurus*.

The fossil leaf (fig. 12) is almost identical with the leaflets of *D. sinensis* (fig. 11). Perhaps an even better example is the specimen figured by Berry as *Comptonia insignis*. Although no rachis is present the conclusion seems inescapable that the specimen represents two leaflets of a compound leaf. The teeth are rather large, but this is perhaps a partial illusion caused by tearing of the leaflets in the notches between the teeth. They can be matched easily with living material. Berry identified this specimen with *C. insignis* from the Florissant lake beds, Florissant, Colorado. This identification, however, cannot be sustained in the presence of the types, which, in the writer's judgment, are not the leaves of *Comptonia* but the leaflets of *Koelreuteria*, whose capsules and seeds, *K. alleni* (Lesquereux) Edwards, are not uncommon in those beds.

Occurrence.—Loc. 1. Types in U. S. Nat. Mus.

RHAMNACEAE

CEANOTHUS IDAHOENSIS Brown, n. sp.

Plate 69, figure 8

Populus zaddachi Heer, JENNINGS, *1920*, Carnegie Mus., (Pittsburgh), Mem., vol. 8, no. 2, p. 406, pl. 24, fig. 6; pl. 25, figs. 1, 2; pl. 26, figs. 1*a*, 2, 3, 5, 6.

Ovate-lanceolate leaves 7 cm. or more long, 3 cm. or more wide; apex elongated, base rounded-cordate; margin crenate-serrate; midrib strong, flanked by two prominent lateral primary veins that curve upward to unite with the first strong secondaries coming off from the midrib in the upper half of the leaf; secondary branches from the lateral primaries and the midrib form widely spaced loops.

Remarks.—This leaf (fig. 8) can be duplicated with the leaves of *Ceanothus americanus* Linnaeus and *C. sanguineus* Pursh; but it differs from the fossil leaves, *C. blakei* Chaney (21), from the Crooked River Basin, Oregon, in having crenate-serrate teeth and a more elongated form. *C. blakei*, according to the illustrations, resembles the more sharply serrate leaves of *C. velutinus* Douglas. It may be that some of or all the specimens of *Populus zaddachi* Heer reported by Lesquereux (22) from the auriferous gravels of California, are also *Ceanothus*, perhaps this species.

Occurrence.—Loc. 5*a*. Type in U. S. Nat. Mus.

RHAMNUS IDAHOENSIS Brown, n. sp.

Plate 69, figure 13

Elliptic leaf, 2 cm. long, 1 cm. wide; margin serrate with low teeth; 5 or 6 pairs of secondary veins leave the midrib at angles of about 45° and form loops with the secondaries above; length of petiole unknown.

Remarks.—This species may be compared favorably with *Rhamnus alnifolia* L'Heritier, a shrub which ranges across the northern United States and Canada to British Columbia and south to California. The presence of teeth distinguishes this species from *R. spokanensis* Berry (23) in the Latah flora.

Occurrence.—Loc. 5*a*. Type in U. S. Nat. Mus.

TRAPACEAE

TRAPA AMERICANA Knowlton

Plate 67, figure 17

Trapa americana KNOWLTON, *1898*, U. S. Geol. Survey, Eighteenth Ann. Rept., pt. 3, p. 733, pl. 102, fig. 7*a*.—BERRY, *1927*, U. S. Nat. Mus., Proc., vol. 72, art. 23, p. 13, pl. 2, figs. 5, 6.

Trapa? occidentalis KNOWLTON, idem, p. 734, pl. 102, fig. 7*b*.

The two-horned specimen figured here is the first to be reported from beds ascribed to or correlated with the Latah formation. It can be duplicated with specimens from the prolific horizon in the Payette formation at Idaho City, Idaho, which was the source of Knowlton's types, and with specimens described by Berry from the Esmeralda formation of western Nevada. An abundance of material indicates great variability in the shape of these fruits. Many specimens when carefully excavated still retain the delicate recurved barbs on the extremities of the horns. No *Trapa* leaves have been reported from these beds.

The genus *Trapa*, now comprising two, possibly three, species endemic to southern Europe, northern Africa, and eastern Asia and recently introduced into the eastern United States, has had a long history in North America. The first specimens to be described were two-horned nuts called *T. borealis* Heer (24) from the Eocene of Alaska. Dawson (25) in 1876 recognized fruits of *Trapa* in the collections of G. M. Dawson from beds "of Laramie age" on the 49th Parallel, referring them to *T. borealis;* and in 1886 reported similar nuts from "Laramie" rocks on the Red Deer and Rosebud River in the badlands of western Canada. At some localities he found both fruits and leaves, the latter being like those called *T.? microphylla* Lesquereux (26) from Point of Rocks, Wyoming, and best illustrated by Ward

(27) as rosettes of leaves from rocks of Fort Union age at Burns Ranch, Montana. *T. wilcoxensis* Berry (28), a smaller species than *T. borealis*, and *T. alabamensis* Berry (29) are from the Eocene and Pliocene, respectively, of the southeastern United States. The latter species probably represents the last stand of *Trapa* in America. Fossil species of *Trapa* have been found in European and Asiatic strata from the Oligocene to the Pleistocene, thus illustrating an holoarctic distribution of the genus from the early Tertiary to the Miocene or Pliocene.

In recent years the four-horned species, *T. natans* Linnaeus, has escaped from cultivation into slow streams of the eastern United States and according to Shannon's graphic description (30) may become a menace to both fishing and navigation.

Occurrence.—Loc. 3. Figured specimen in U. S. Nat. Mus.

Loasaceae

Mentzelia occidentalis (Berry) Brown, n. comb.

Plate 69, figures 16, 17

Hibiscus? occidentalis Berry, *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 258, pl. figs. 13–15; *1934*, U. S. Geol. Survey, Prof. Paper 185, p. 120.

These objects are winged seeds whose distinctive character is the finely reticulated surface on both the seed and wing, the best display being on the seed. The wrinkling of the thin wing produces an effect simulating hairs or striations. There is much variation in the shape of these winged seeds, especially near the base, which may be rounded, abruptly truncate, or narrowed to a blunt point.

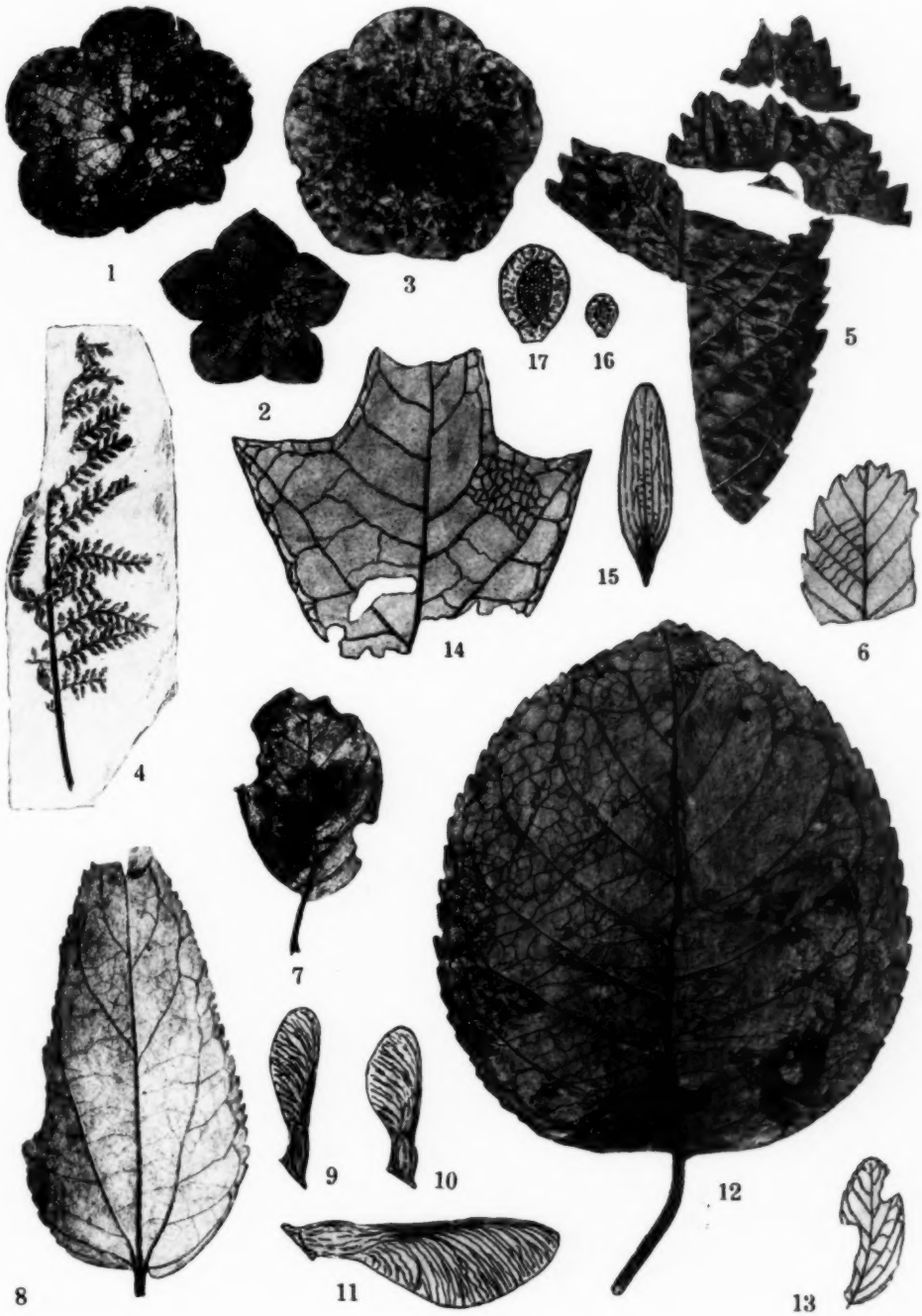
The original suggestion of malvaceous affinity caused the writer to examine all the malvaceous seeds available in Washington seed collections, but without success in finding a living species affording satisfactory comparison with the fossils. He did find, however, with the help of Alec C. Martin, of the Bureau of Biological Survey of the U. S. Department of Agriculture, that the fossils can be matched rather closely with the seeds of some species of *Mentzelia*, particularly *M. decapetala* (Pursh) Urban and Gilg, a species common on the western plains. The 60 species, more or less, of existing *Mentzelia* are confined to the western hemisphere. They live in dry or moist soil in sunny situations, and their seeds when winged are adapted to dispersal by wind. Thus the presence of the seeds and the absence of leaves and other parts of what was very likely an herbaceous *Mentzelia*, can be readily accounted for in the water-laid deposits of the Latah formation.

Occurrence.—Locs. 2, 4. Figured specimen (from Loc. 2) in U. S. Nat. Mus.

Explanation of Plate 69

All figures natural size, except 17

Figs. 1–3—Calyces, *Porana speirii* Lesquereux. Republic, Wash. (figs. 1, 2); Fossil, Wyo. (fig. 3). (p. 583)
4—*Chamaebatia prefoliolosa* Brown, n. sp. Salmon, Idaho. (p. 578)
5, 6—*Amelanchier dignatus* (Knowlton) Brown, n. comb. Salmon, Idaho. (p. 577)
7—*Symphoricarpos salmonensis* Brown, n. sp. Salmon, Idaho. (p. 583)
8—*Ceanothus idahoensis* Brown, n. sp. Salmon, Idaho. (p. 581)
9–11—Seeds, *Acer negundoides* MacGinitie. Bridge Creek, Oreg. (figs. 9, 10); Spokane, Wash. (fig. 11). (p. 580)
12—*Malus idahoensis* Brown, n. sp. Reconstructed portion based on the counterpart. Salmon, Idaho. (p. 578)
13—*Rhamnus idahoensis* Brown, n. sp. Salmon, Idaho. (p. 581)
14, 15—Leaf and seed, *Liriodendron hesperia* Berry. Spokane, Wash. (p. 577)
16, 17—Seed, *Mentzelia occidentalis* (Berry) Brown, n. comb., nat. size and ×3. Spokane, Wash. (p. 582)



Brown, Miocene Plants

OLEACEAE

FRAXINUS IDAHOENSIS Brown, n. sp.

Plate 67, figures 14, 18

Fraxinus?, samaras. BERRY, *1934*, U. S. Geol. Survey, Prof. Paper 185, p. 122, pl. 24, figs. 3, 4.

The fragments described by Berry from White Bird, Idaho, and the entire specimen figured here, are the same species and compare most favorably not with any existing American species but with *Fraxinus inopinata* Lingelsh, of Yunnan, and *F. platypoda* Oliver, of Hupeh Province, China. These species have unusually large lanceolate samaras in which the seed proper is concealed by the wing substance, so that it is not an evident feature. The fossils show the same characters—the concealed seed, the striated surface, and the bilateral lanceolate blade.

Figure 18 represents three fragmentary leaflets of a compound leaf. The widely spaced somewhat irregular camptodrome secondary veins, the serrate margins, and the general form of the leaflets suggest that they belong to *Fraxinus* and very likely to the species that produced the seed.

Occurrence.—Loc. 3. Types in U. S. Nat. Mus.

ARCTOSTAPHYLOS CUNEATA Brown, n. sp.

Plate 67, figure 20

Leaf obovate, 1.5 cm. long, 8 mm. wide; apex rounded, base cuneate to a short petiole; venation indistinct; lowest secondaries branch from the midrib at very small angles and run upward well toward the apex of the leaf.

Remarks.—In shape, texture, and venation this leaf can be matched readily with leaves of *Arctostaphylos uva-ursi* Sprengel. It might also be compared with the leaves of *Ceanothus cuneatus* Nuttall. As between the two, it seems that *Arctostaphylos* is a better ecologic choice than *Ceanothus*.

Occurrence.—Loc. 5*a*. Type in U. S. Nat. Mus.

CAPRIFOLIACEAE

SYMPHORICARPOS SALMONENSIS Brown, n. sp.

Plate 69, figure 7

An eroded round-elliptic leaf 3 cm. long, 2 cm. wide, with entire margin; petiole 1 cm. long; secondary veins camptodrome, leave the midrib at an angle of about 70°, fork and loop near the margin; tertiary venation obscure.

Remarks.—This leaf compares very well with those of a number of American species of *Symphoricarpos*, particularly the Indian currant or coral berry, *S. orbiculatus* Moench, and the snowberry, *S. albus* Blake.

Occurrence.—Loc. 5*a*. Type in U. S. Nat. Mus.

OBJECTS OF UNCERTAIN IDENTITY

PORANA SPEIRII Lesquereux

Plate 69, figures 1, 2, 3

Porana speirii LESQUEREUX, *1883*, U. S. Geol. Survey Terr., Rept., vol. 8, p. 172, pl. 28, fig. 15.—CHANEY, *1927*, Carnegie Inst. Washington, Pub. 346, p. 134.

Convolvulaceous? flower, KIRCHNER, *1898*, St. Louis Acad., Trans., p. 187, pl. 15, fig. 2.

Florissantia physalis KNOWLTON, *1916*, U. S. Nat. Mus., Proc., vol. 51, no. 2151, p. 270.

Porana similis KNOWLTON, idem, p. 288, pl. 27, figs. 1, 2.

Hydrangea bendirei (Ward) Knowlton, BERRY *1929*, U. S. Geol. Survey, Prof. Paper 154, p. 251, pl. 52, fig. 7.

Three characters distinguish these objects: 1. Lobes 5, pointed or rounded, connate. 2. Principal veins parallel; midrib no stronger than the rest; connecting veinlets roughly perpendicular to the principal veins, giving the appearance of a neat, regular, lacework pattern. 3. Absence of pistil and stamens, suggesting that they are calyces not corollas. Comparison of these specimens with those cited in the synonymy leads to the conclusion that all belong to the same species. Their connate lobes eliminate them from *Cornus* and *Hydrangea*, as now defined, for the colored bracts of *Cornus* are separate, and the sterile flowers of *Hydrangea* have separate petals, or at least are very deeply 4-

parted, sometimes 5-parted, and their venation is pinnate, not parallel. The flowers called *Hydrangea bendirei* (Ward) Knowlton (31) and *H. florissantia* Cockerell (32) are deeply parted, with pinnate venation, and are therefore considered to be true *Hydrangea* flowers, although perhaps not the same species.

A large handsome specimen of this or a closely related species was described as *Viburnum palmatum* Chaney and Sanborn (33) from upper Eocene or lower Oligocene beds at Goshen, Oregon. The authors say:

> . . . the calyx has been referred to *V. palmatum* which corresponds to that of the calyx of *V. opulus* in its comparatively large size, as well as in its form and other characters.

It is true that these fossil calyces resemble the sterile flowers of *V. opulus* Linnaeus in size and form, but their parallel venation with the conspicuous pattern of cross-veinlets cannot be reconciled easily with the pinnate venation and irregular system of nearly invisible veinlets of modern *Viburnum* flowers. A specimen (fig. 3) similar to but smaller than that from Goshen, and so like the type from Florissant, Colorado, that I hesitate to draw distinctions, has just appeared in a collection made by E. C. Case from the Green River formation at Fossil, Wyoming, now at the University of Michigan Museum of Paleontology. It is one more link in the chain of evidence showing a close relationship between the Green River flora and that from the Florissant lake beds.

That the fossils represent *Porana* of the Convolvulaceae may be doubted, but the venation matches remarkably well. Those Florissant species called *P. tenuis* Lesquereux and *P. cockerelli* Knowlton (which is the same as *P. tenuis*) compare well with the tough calyces and capsules of *P. racemosa* Roxburg and other species, but no leaves suggesting *Porana* have yet been reported from the Florissant lake beds.

The fossils may also be compared with the leathery calyces of several Central and South American species of *Heisteria* of the Olacaceae, but the comparison fails to carry complete conviction because the venation of *Heisteria* calyces, although irregularly parallel, is concealed and also lacks the clearly defined system of cross-veinlets shown in the fossils.

Whatever the true identity of the fossils may be, they at least are easily recognizable and should be looked for in the Latah flora, from which they have not yet been reported. Thus far they have been found in deposits at Fossil, Wyoming; Goshen and Bridge Creek, Oregon; Republic, Washington; and Florissant, Colorado. Should they fail completely in the Latah and Mascall floras they will acquire value as "index" fossils for the early Tertiary of the northwestern states.

Occurrence.—Loc. 1 (figs. 1, 2); figured specimens in Public Museum, Spokane, Washington. Green River formation (middle Eocene) at Fossil, Wyoming (fig. 3); figured specimen in Mus. Paleont. Univ. Michigan.

CARPOLITHUS HIBISCOIDES Brown, n. sp.

Plate 67, figure 19

This is a ripe fruit of five, spotted or glandular locules, only three of which are shown in the figure, because in the specimen itself the other two were concealed in the matrix beneath. Each locule shows a median line along which, near the apex, dehiscence has begun. The left side of the locule on the right is pierced by a small round hole, evidently the work of an insect parasite. Beneath the locules are the remains of what appear to have been bracts. Length of peduncle 1.3 cm.

Remarks.—This is apparently a malvaceous fruit, similar in general appearance to those produced by species of *Abutilon*, *Hibiscus*, and *Gossypium*. However, neither seeds nor leaves of definite malvaceous character have yet been identified from these beds.

Occurrence.—Loc. 4. Type in U. S. Nat. Mus.

CONCLUSIONS

Eventually some of the new species or new combinations discussed here may prove to be significant in determining the geologic age of the floras to which they belonged; but further study than the writer has been able to give will be necessary to evaluate their ecologic connotations properly. Only a brief statement is possible now.

Callitris, *Cercidiphyllum*, *Dipteronia*, *Keteleeria*, *Trapa*, and perhaps some species of other genera if their identity and correlation were certainly known, belong in that increasing list of once holarctic Tertiary plants, e.g., *Ailanthus*, *Amygdalus*, *Ginkgo*, *Glyptostrobus*, *Koelreuteria*, and *Paliurus*, that became extinct in the western hemisphere but survived either as the same or as intimately derived species in the eastern hemisphere. *Sequoia*, once widely distributed in the North Temperate zone, is now confined to California and Oregon. *Chamaebatia*, recorded here as fossil for the first time, is restricted to the western slope of the Sierra Nevada. *Cedrela* appears to have been an invader from the south; it is now distributed in the tropics and subtropics of America and Asia.

Most genera in the list still have a more or less continuous holarctic distribution, but many of the species represented find their closest allies in or adjacent to the regions where the fossils were found. Two, *Liriodendron* and *Taxodium*, however, belong with that large number of genera that no longer have representatives in western America but have survivals in both eastern America and eastern Asia, e.g., *Arisaema*, *Carpinus*, *Castanea*, *Diospyros*, *Fagus*, *Hicoria*, *Hydrangea*, *Liquidambar*, *Magnolia*, *Nyssa*, *Sapindus*, *Sassafras*, *Sophora*, *Tilia*, and *Ulmus*.

The relationship of the latter floras to one another and the geologic, geographic, and climatic circumstances that brought about their present segregation, were first given vivid, detailed statement in a series of papers by Asa Gray, beginning in 1859 (34). More recently a summary and an elaboration of this subject were contributed by Berry (35) and Fernald (36), respectively. C. V. Piper has discussed the origin and ecology of the present flora of the northwestern states (37).

To the picture portrayed in these papers of botanic events in the northern hemisphere during and since the Tertiary, the fossil record is constantly adding clarifying lines and colors. The result is a growing knowledge of the composition and ecology of these fossil floras that will, it is hoped, ultimately furnish a satisfactory basis for a more precise determination of their geologic age. At present it is the writer's tentative opinion, in part differing from the official classification of the U. S. Geological Survey, that the floral and stratigraphic evidence indicates that the ages of the strata at the several fossil localities referred to in this paper are approximately as follows:

Burns Ranch, Mont.: Lower Eocene
Fossil, Wyo.: Middle Eocene

Goshen, Lane County, Oregon: Upper Eocene or lower Oligocene

Florissant, Colo.: Upper Oligocene or lower Miocene

Bridge Creek, John Day Valley, Oregon: Lower Miocene

Republic, Wash.: Lower Miocene

Salmon, Idaho: Lower Miocene

Missoula, Mont.: Lower Miocene

Idaho City, Idaho (part of Payette formation): Lower Miocene

Spokane, Wash. (part of Latah formation): Middle Miocene

Potlatch Creek, Idaho: Middle Miocene

White Bird, Idaho: Middle Miocene

Localities in the Mascall formation: Upper Miocene

Trout Creek, southeastern Oregon: Upper Miocene

REFERENCES

1. BERRY, E. W., Miocene plants from Idaho: *U. S. Geol. Survey, Prof. Paper* 185, p. 103, pl. 19, fig. 4, 1934.
2. ELLS, S. C., Fossil wood discovered in Alberta bituminous sands: *Canadian Min. Jour.*, vol. 52, no. 7, pp. 171–172, 1931.
3. BERRY, E. W., A revision of the flora of the Latah formation: *U. S. Geol. Survey, Prof. Paper* 154, p. 244, pl. 63, fig. 9; pl. 64, fig. 1, 1929. The latter figure is upside down; the retouched peduncle represents two styles distinctly separate in the specimen, and portions of the wings should be shown near the base of the seed.
4. HEER, OSWALD, *Flora Tertiaria Helvetiae*, vol. 1, p. 47, pl. 16, fig. 20 (twig), 1855. Saporta, Gaston de, *Etudes sur la végétation du sud-est de la France à l'époque Tertiaire*, part 1, pp. 56–57, pl. 3, fig. 1 (twig); pl. 2, fig. 6*A*, *B* (cone); pl. 2, fig. 6*C* (seed), 1863.
5. SAPORTA, GASTON DE, *op. cit.*, pp. 185–187, pl. 3, fig. 2, *A*, *B*, *C* (twigs), *D*, *E*, *E'* (cones), *F* (seed), 1863.
6. BERRY, E. W., The flora of the Woodbine sand at Arthurs Bluff, Texas: *U. S. Geol. Survey, Prof. Paper* 129, p. 166, 1922.
7. BERRY, E. W., Tertiary floras from British Columbia: *Canada Geol. Survey, Bull.* 42, p. 109, pl. 13, figs. 1–4, 1926; On fossil plants from the Paskapoo formation of Alberta: *Roy. Soc. Canada, Trans.*, 3d ser., vol. 20, pt. 2, sec. 4, p. 196, 1926; Fossil plants from the Cypress Hills of Alberta and Saskatchewan: *Canada Nat. Mus., Bull.* 63, pp. 20–22, pl. 5, figs. 2, 3, 1930.
8. MATHEISEN, F. J., Notes on some fossil plants from east Greenland: *Meddelelser om Grönland*, Bd. 85, Nr. 4, p. 5, 1932.
9. WARD, L. F., Types of the Laramie flora: *U. S. Geol. Survey, Bull.* 37, p. 19, pl. 4, figs. 1–4, 1887.
10. NEWBERRY, J. S., The later extinct floras of North America: *U. S. Geol. Survey, Mon.* 35, p. 44, pl. 27, fig. 1, 1898.
11. WARD, L. F., Types of the Laramie flora: *U. S. Geol. Survey, Bull.* 37, p. 85, pl. 39, fig. 1, 1887.
12. LESQUEREUX, LEO, Report on the fossil plants of the auriferous gravel deposits of the Sierra Nevada: *Mus. Comp. Zool. (Harvard Univ.), Mem.*, vol. 6, no. 2, p. 11, pl. 8, figs. 1–8, 1878.
13. JENNINGS, O. E., Fossil plants from the beds of volcanic ash near Missoula, western Montana: *Carnegie Mus. (Pittsburgh), Mem.*, vol. 8, no. 2, p. 406, pl. 24, fig. 6; pl. 25, figs. 1, 2; pl. 26, figs. 1, 1*a*, 2, 3, 5, 6, 1920.
14. CHANEY, R. W., The flora of the Eagle Creek formation: *Walker Mus. Univ. Chicago, Contr.*, vol. 2, no. 5, p. 173, pl. 14, fig. 4, 1920.
15. ENDO, SEIDO, Discovery of *Liriodendron* leaves from the Neogene of Japan: *Imp. Acad. Japan, Proc.*, vol. 10, no. 9, art. 166, pp. 590–593, 2 text-figs., 1934.
16. MUIR, JOHN, *Our national parks*, p. 143, 1902.
17. KNOWLTON, F. H., Fossil flora of the John Day Basin, Oregon: *U. S. Geol. Survey, Bull.* 204, p. 71, pl. 12, figs. 1–3, 1902.
18. KNOWLTON, F. H., Flora of the Latah formation of Spokane, Washington, and Coeur d'Alene, Idaho: *U. S. Geol. Survey, Prof. Paper* 140, p. 50, pl. 29, fig. 12, 1926.
19. BERRY, E. W., A revision of the flora of the Latah formation: *U. S. Geol. Survey, Prof. Paper* 154, p. 260, pl. 58, fig. 4, 1929.
20. BERRY, E. W., *idem*, p. 254, pl. 63, fig. 4.
21. CHANEY, R. W., Geology and paleontology of the Crooked River Basin, with special reference to the Bridge Creek flora: *Carnegie Inst. Washington, Pub.* 346, p. 128, pl. 16, figs. 4, 6, 9, 1927.
22. LESQUEREUX, LEO, Report on the fossil plants of the auriferous gravel deposits of the Sierra Nevada: *Mus. Comp. Zool. (Harvard Univ.), Mem.*, vol. 6, no. 2, p. 11, pl. 8, figs. 1–8, 1878.
23. BERRY, E. W., A revision of the flora of the Latah formation: *U. S. Geol. Survey, Prof. Paper* 154, p. 257, pl. 57, figs. 4, 5, 1929.
24. HEER, OSWALD, *Flora fossilis arctica*, vol. 2, no. 2, *Flora fossilis alaskana*, p. 38, pl. 8, figs. 9–14, 1869.
25. DAWSON, J. W., On fossil plants from the

Laramie formation of Canada: *Roy. Soc. Canada, Trans.*, vol. 4, sec. 4, p. 31, pl. 2, fig. 19, 1886.

26. LESQUEREUX, LEO, *U. S. Geol. and Geog. Survey Terr., Ann. Rept.* 1874 [1876], p. 304; idem, *U. S. Geol. Survey Terr., Rept.*, vol. 7, p. 295, pl. 61, figs. 16–17*a*, 1878.
27. WARD, L. F., Types of the Laramie flora: *U. S. Geol. Survey, Bull.* 37, p. 64, pl. 28, figs. 2–5, 1887.
28. BERRY, E. W., Two new Tertiary species of *Trapa: Torreya*, vol. 14, pp. 105–108, text-figs. 1–3, 1914; The lower Eocene floras of southeastern North America: *U. S. Geol. Survey, Prof. Paper* 91, p. 326, pl. 101, figs. 7–9, 1916.
29. BERRY, E. W., The flora of the Citronelle formation: *U. S. Geol. Survey, Prof. Paper* 98, p. 203, pl. 47, figs. 9, 10, 1916.
30. SHANNON, E. V., A weed attacks: *Nature Mag.*, vol. 16, pp. 122–124, 1930.
31. KNOWLTON, F. H. Fossil flora of the John Day Basin, Oregon: *U. S. Geol. Survey, Bull.* 204, p. 60, pl. 9, figs. 6, 7, 1902; *U. S. Geol. Survey, Prof. Paper* 140, p. 42, pl. 24, fig. 6, 1926.
32. COCKERELL, T. D. A., Descriptions of Tertiary plants: *Am. Jour. Sci.*, vol. 26, p. 67, text-fig. 2, 1908.
33. CHANEY, R. W., and SANBORN, ETHEL I., The Goshen flora of west-central Oregon: *Carnegie Inst. Washington, Pub.* 439, p. 97, pl. 40, fig. 4, 1933.
34. SARGENT, C. S., *Scientific papers of Asa Gray*, vol. 2. Houghton, Mifflin Co., 1889—The flora of Japan, pp. 125–141 [1859]; Sequoia and its history, pp. 142–175 [1872]; Forest geography and archaeology, pp. 204–233 [1878]; Characteristics of the North American flora, pp. 260–282 [1884].
35. BERRY, E. W., A revision of the flora of the Latah formation: *U. S. Geol. Survey, Prof. Paper* 154, pp. 232–233, 1929; Former land connection between Asia and North America as indicated by the distribution of fossil trees. *Fifth Pan Pacific Science Congress*, pp. 3093–3016, 1934.
36. FERNALD, M. L., Specific segregations and identities in some floras of eastern North America and the Old World: *Rhodora*, vol. 33, pp. 25–63, 1931. See bibliography.
37. PIPER, C. V., Flora of the State of Washington: *U. S. Nat. Herb., Contr.*, vol. 11, 1906.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 588–592, PL. 70, OCTOBER, 1935

FURTHER NOTES ON THE CRETACEOUS PELECYPOD GENUS *DIPLOSCHIZA*

LLOYD WILLIAM STEPHENSON
U. S. Geological Survey, Washington, D. C.

ABSTRACT

Newly studied material extends the geographic range of *Diploschiza cretacea* Conrad and confirms its value as a zonal marker. A new species in the genus is described.

Since the publication of my paper entitled, *The genus* Diploschiza *from the Upper Cretaceous of Alabama and Texas* (1), additional data on the occurrence and distribution of the genus have been obtained from several sources and seem worthy of record.

Soon after the appearance of my paper Miss Winnie McGlamery, of the Alabama Museum of Natural History, Tuscaloosa, wrote to me (letter dated October 8, 1934) that she had found in the Schowalter collection there a tray containing 80 specimens of *Diploschiza cretacea* Conrad, which had been collected by Dr. E. R. Schowalter near Uniontown, Perry County, Ala. Later she kindly lent this lot to me for study, and permitted me to retain 20 specimens for the National Museum's collections. These shells proved to be specifically identical in all respects with those collected by me on Tombigbee River in the bluff at Demopolis, and at Jones Bluff, near Epes. Had I known of this collection I would have selected the neotypes from it instead of the collection from Demopolis. Indeed the specimen which Doctor Schowalter sent to Doctor Conrad, and which served as the basis for the new genus and species, may have been selected from this lot. There is, however, no way of verifying this possibility.

Miss McGlamery also submitted three right valves of *D. cretacea* from the Schowalter collection, from a locality $6\frac{1}{2}$ miles north of Safford, Dallas Co., Alabama; these were returned to her.

In March, 1935, Mr. A. C. Munyan and I visited the Uniontown district and collected typical specimens of *Diploschiza cretacea* from the Selma chalk at the three following localities:

Public road ditch 0.6 mile south of Uniontown, Perry Co., Alabama (U. S. Geol. Survey coll. 16,995).

U. S. Highway No. 80, 3.3 miles west-northwest of Faunsdale, Marengo Co., Alabama (U. S. Geol. Survey coll. 16,994).

State Highway No. 22, ditch and nearby bald spots, $4\frac{3}{4}$ miles west of Orrville, Dallas Co., Alabama (U.S.Geol. Survey coll. 17,002).

Occasional specimens among all of these lots are weakly and finely striated, in a manner similar to that

of the variety *D. cretacea striata* Stephenson, but no specimens as strongly marked as the types were found. According to the label the types of this variety were found on the "Prairies of Massillon," Dallas Co., Alabama. The village of Massillon is surrounded by an expanse of open, rolling prairie, but at the time of my visit there in March I did not succeed in finding any exposures of the Selma chalk, which underlies that district, and I was unable to verify the occurrence of the variety there; there is, however, no reason to doubt that the types came from somewhere in the vicinity of Massillon.

In correspondence dated February 8 and March 4, 1935, Mr. F. F. Mellen, Graduate Assistant, Mississippi State College (formerly Mississippi Agricultural and Mechanical College), Starkville, informed me that he had found among the collections at the College some thin pieces of limestone containing many specimens of *Diploschiza cretacea* Conrad, labelled as having come from the Potts farm, about 15 miles southwest of Columbus, Mississippi; and that he and Dr. P. H. Dunn had collected shells of the species in calcareous clay bluffs on Tibbee Creek, 2 miles south of West Point, Mississippi. I have not seen these specimens, but the localities would seem to be at about the right geographic position to fall within the belt of outcrop of the zone carrying *D. cretacea*, if extended from Alabama into that state. Under date of June 22, 1935, Mr. Mellen sent me 17 specimens of *D. cretacea* which he collected from a thin stratum in the Selma chalk, near the crest of a hill east of the home of George Mitchell, about 2 miles south of Tupelo, Lee County, Mississippi (U. S. Geol. Survey coll. 17,045). Some of these shells show a weak development of radiating striae.

The data now on record determine the linear extent of the *Diploschiza cretacea* zone in the eastern Gulf region to be not less than 165 miles, from the vicinity of Orrville, Dallas Co., Alabama, to the vicinity of Tupelo, Lee Co., Mississippi.

In letters dated November 19 and 25, and December 5, 1934, Mr. Mellen reported having found many specimens of *Diploschiza* at three localities in the Oktibbeha tongue of the Selma chalk (2) in the vicinity of Starkville, as follows:

> Three-quarters of a mile northeast of Mississippi State College.
>
> One-quarter of a mile northeast of the Young Men's Christian Association building.
>
> About 4 miles northwest of Starkville in NE. ¼ sec. 16, T. 19 N., R. 14 E.

At my request Mr. Mellen submitted specimens of these shells from the last named locality and they proved to be a larger and more strongly ornamented form of *Diploschiza* than that represented by the variety *D. cretacea striata* Stephenson. Furthermore, I found that in former years I had collected many of the same kind of shells at the same stratigraphic position, at four localities in Mississippi and at three localities near Livingston, Alabama; these included many individuals and had been identified and labelled as *Plicatula* sp., for which reason they were

overlooked at the time my earlier paper on the genus *Diploschiza* was in preparation. It is now proposed to record these specimens under the new specific name, *Diploschiza melleni* (see below).

In my earlier paper on *Diploschiza* (p. 277) I called attention to several English species referred by their authors to the genus *Plicatula*, the published illustrations of which suggest that they belong rather to Conrad's genus *Diploschiza*. In a letter dated October 15, 1934, Dr. Henry Woods called my attention to the fact that in an appendix to his work, *A monograph of Cretaceous Lamellibranchia of England* (vol. 1, pt. 5, pp. 225–226, 1903) he had transferred one of the species mentioned above, *Plicatula sigillina* Woodward, to the genus *Dimyodon*, and that he had satisfied himself that the species *sigillina* was a synonym of *Dimyodon nilssoni* (Hagenow); he remarked, however, that he had not seen the adductor impressions on any specimens of *Plicatula sigillina*.

Among the dozens of specimens of *Diploschiza* which I have examined I have failed to find one on which the adductor scars are preserved. Should the apparent absence of adductor scars prove to be due to the failure of preservation of an inner shell layer, and should *Diploschiza* Conrad (1866) and *Dimyodon* Munier-Chalmas (1886) prove to be congeneric, the former name would be the valid one, since it antedates the latter by 20 years. The genotype of *Dimyodon* is *D. schlumbergeri* Munier-Chalmas, from the Jurassic (Bathonien) of Heronvillette, France, the original published figures of which, in Fischer's manual (3), show two adductor scars and do not show radiating riblets on the interior. Grönwall (4) has discussed the occurrence and systematic position of *Dimyodon*, but his conclusion that this dimyarian genus is closely allied to the monomyarian genus, *Spondylus* Linnaeus, cannot be accepted as valid; the so-called ridge-form teeth of *Dimyodon* are not true teeth, but are crura, present on both valves, between the pairs of which the resilium was seated.

SYSTEMATIC DESCRIPTIONS

DIPLOSCHIZA MELLENI Stephenson, n. sp.
Plate 70, figures 1–12

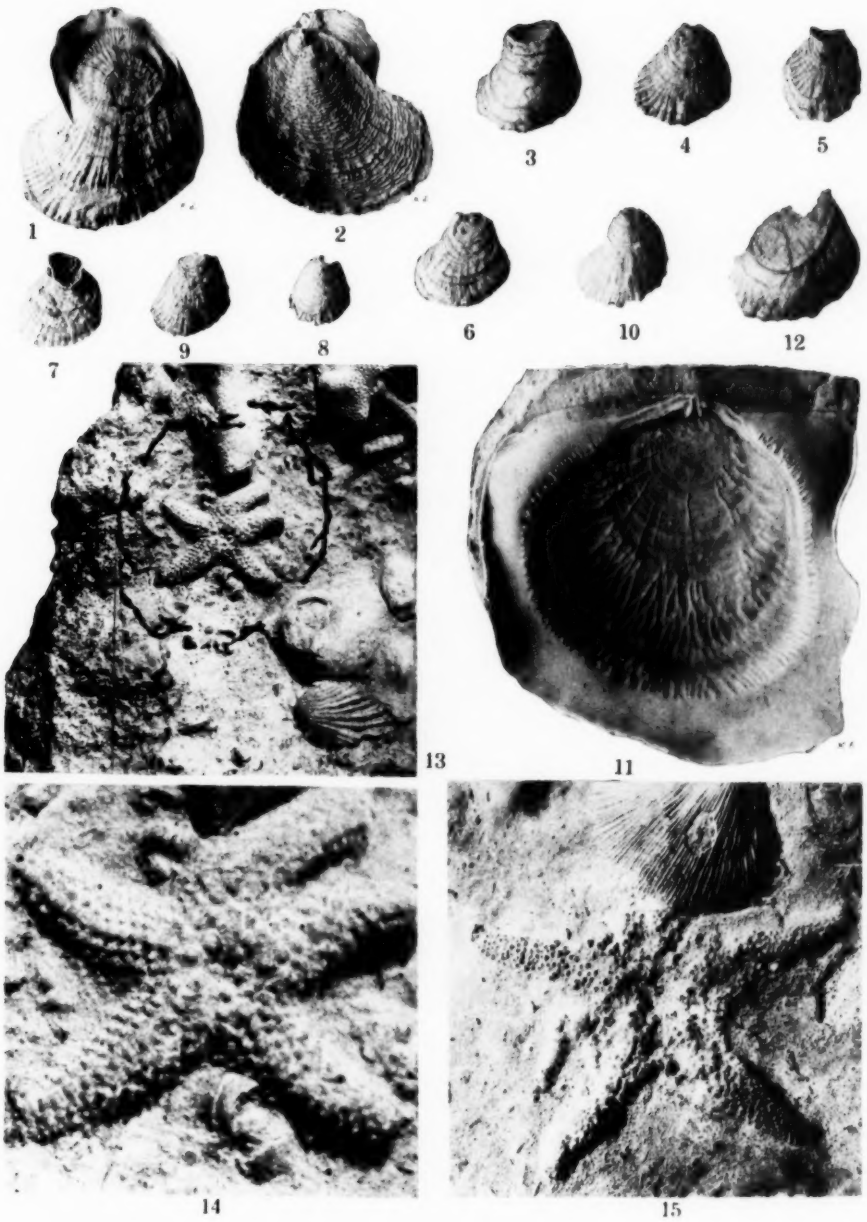
Shell small, broadly subovate to subtrigonal in outline, inequivalve, inequilateral. Beaks small, nonprominent, not projecting above the hinge line. Right valve compressed to moderately inflated in different individuals; although varying

EXPLANATION OF PLATE 70

FIGS. 1–12—*Diploschiza melleni* Stephenson, n. sp. 1, 2, Holotype, ×2, U. S. Nat. Mus. 75,484; exterior of right valve, and interior of a young valve attached to the umbonal portion; exterior of left valve. 3–10, Paratypes, ×1, U. S. Nat. Mus. 75,485; exteriors showing variation in form, sculpture, and size of scar of attachment. 11, Paratype, ×6, U. S. Nat. Mus. 75,486; interior showing the pair of crural ridges enclosing the resilifer, and other features. 12, Paratype, ×1, U. S. Nat. Mus. 75,487; exterior of large specimen with costae poorly developed. (p. 590)

13, 14—*Hudsonaster narrawayi* (Hudson) var. *mackvillensis* Jones, n. var., holotype, ×1 and ×3, Galena limestone, Mackville, Wisconsin; Lawrence Coll. Mus. 211. (p. 594)

15—*Promopalaeaster wisconsinensis* Jones, n. sp., holotype, ×1, Richmond shales, Bay Settlement, Wisconsin; Lawrence Coll. Mus. 212, (p. 594)



Stephenson, Cretaceous Pelecypods
Jones, Ordovician Starfish

greatly in form this valve is generally broadly domed with the greatest inflation at or above the midheight. The lower posterior portion of many individuals swings strongly toward the rear, but this is an exceedingly variable feature.

Surface of right valve ornamented with numerous, low, closely spaced, radiating costae which vary greatly in strength on the same and on different individuals; away from the beak the number of costae increase both by division and by intercallation in the interspaces; an occasional specimen exhibits a very weak development of costae. Left valve rather deeply concave on the holotype, but varying on different individuals from slightly convex to strongly concave; it is conspicuously marked with numerous, closely spaced, overlapping growth lamellae, and obscurely marked on some specimens with radiating ribs.

Hinge of right valve long, narrow, edentulous, with a pair of centrally placed, small, short, diverging crural ridges which project internally a little below the hinge; a resilium was doubtless seated in the narrow, triangular space between these ridges. The hinge of the left valve has not been seen in well preserved specimens, but imperfect shells appear to show that it possesses a pair of small crura, inclosing the resilifer as on the right valve. The inner surface exhibits numerous, sharp, radiating riblets which may fork several times before reaching their terminus along or just beyond a concentric line or ridge which lies 1 to 4 mm. within the margin of the shell; the surface between the ends of the riblets and the margin is smooth; the concentric line or ridge just mentioned is finely crenulated and extends around on the inner surface to the pair of crural ridges on the hinge margin. No trace of adductor scars has been seen on any of the many available shells of this or other species of the genus.

Attached to the umbonal portion of the holotype is the right valve of a young individual (Pl. 70, fig. 1) which probably lodged there after the death of the former; the scar of attachment of the holotype is partly uncovered at the edge of this young shell and is apparently quite small; on other shells this scar varies from small to large.

Dimensions of the holotype: Length 13 mm., height 13 mm., thickness 4.5 mm. A few shells in the collections reach a maximum length or height of 20 mm.

The species is named in honor of Mr. Frederic Francis Mellen.

Remarks.—Diploschiza melleni is remarkable for its diversity of outline and form, and for the variation in the strength of development and coarseness of the radiating costae.

Compared with the nearly smooth *Diploschiza cretacea* Conrad this species averages larger, and commonly departs noticeably from circularity in outline, becoming elongated in the direction of the height or in a postero-ventral direction; another striking difference is the nearly universal development of conspicuous radiating costae. The radial ornamentation of the variety *D. cretacea striata* is essentially like that of the present species except that the costae are much finer and weaker; it seems likely that this variety is ancestral to *D. melleni* which is known only from a stratigraphically higher position.

This species has not been found west of the Mississippi Embayment but if its range extended that far it should be found in the Corsicana marl of the Navarro group, which is believed to be contemporaneous with the chalk carrying the species in Mississippi and Alabama.

Types.—Holotype, U. S. Nat. Mus. 75,484; eight paratypes from the same locality, U. S. Nat. Mus. 75,485; one paratype from another locality near Livingston, U. S. Nat. Mus. 75,486; another paratype from a locality near Starkville, Miss., U. S. Nat. Mus. 75,487.

Occurrence in Alabama.—Uppermost beds of Selma chalk (=age of Oktibbeha tongue of Selma chalk in Mississippi): Bald spot in Coatopa road, about 2½ miles southeast of Livingston, Sumter Co. (U. S. Geol. Survey coll. 6797; local-

ity of holotype and all but two paratypes); bald spot in same road, about 2 miles southeast of Livingston (U.S.G.S. coll. 6787); old Ramsey road near bridge (now abandoned) over Sucarnoochee Creek, 0.35 mile northwest of the courthouse at Livingston (U.S.G.S. coll. 6799; locality of one paratype).

Occurrence in Mississippi.—Oktibbeha tongue of Selma chalk: Gullies on grounds of Agricultural and Mechanical College east of the buildings, near Starkville, Oktibbeha Co. (U.S.G.S. coll. 6844; locality of one paratype); gullies on Osborn road about 3 miles northeast of Starkville (U.S.G.S. coll. 6846); Lee Pearson's place on Houston road, on slope facing Trim Cane Creek, 3 miles northwest of Starkville (U.S.G.S. coll. 6847); bluff on Trim Cane Creek at a place known as Stony Point or Rocky Point, 4 miles north by west of Starkville (collected and donated by F. F. Mellen; U.S.G.S. coll. 17043); Shuqualak road, half a mile south of bridge over Running Water Creek, 5 miles south of Macon, Noxubee Co. (U.S.G.S. coll. 6839).

REFERENCES

1. STEPHENSON, L. W., The genus *Diploschiza* from the Upper Cretaceous of Alabama and Texas: *Jour. Paleontology*, vol. 8, no. 3, pp. 273–280, pl. 38, 1934.
2. —— Tongue, a new stratigraphic term, with illustrations from the Mississippi Cretaceous: *Washington Acad. Sci., Jour.*, vol. 7, pp. 248–250, 1917; The groundwater resources of Mississippi: *U. S. Geol. Survey, Water-Supply Paper* 576, pp. 37–38, 1928.
3. FISCHER, PAUL, *Manuel de Conchyliologie*, p. 937, text-fig. 705, 1886.
4. GRÖNWALL, K. A., On the occurrence of the genus *Dimyodon*, Mun.-Chalm., in the Mesozoic rocks of Great Britain: *Geol. Mag.*, dec. 5, vol. 3, pp. 202–205, 1906.

Note: This paper is published with the permission of the Director of the U. S. Geological Survey. The manuscript was received by the editor of the Journal July 17, 1935.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 593–595, PL. 70, OCTOBER, 1935

ORDOVICIAN STARFISH OF WISCONSIN

JEANETTE JONES
Lawrence College, Appleton, Wisconsin

ABSTRACT

A new variety of *Hudsonaster narrawayi* (Hudson), from the Galena limestone, and a new species of *Promopalaeaster*, from the Richmond shales, are the first starfish found in the Ordovician of Wisconsin.

Although starfish are widely distributed in Upper Ordovician strata of North America, and occur in Middle Ordovician strata, none have yet been discovered in the Lower Ordovician.

The asteroids are not abundant in any period. Less than 200 species have been described from the entire Paleozoic of the world. Although there is great similarity between American and British Paleozoic asterozoan faunas the relationship is generic, rather than specific. Only 74 species have been described from the North American Paleozoic.

The rarity of starfish may be accounted for by the weak structure of the test. Unless immediate burial takes place the skeleton is destroyed by the separation of the plates. Under such conditions and with the added fact that starfish usually occur singly, they are among the rarest of all Paleozoic fossils and are considered the "choicest" of Museum specimens. The best specimens of fossil starfish are sharp impressions in fine-grained shales and shaly sandstones.

Although many short articles have been written on the Paleozoic starfish the most recent outstanding work in the United States is Schuchert's general revision (5), which gives special attention to the North American fossil starfish and makes an exhaustive review of all heretofore described Asteroidea. A similar study has been made of the British Paleozoic Asteroidea by Spencer (6), of which part 1, 1914, and part 2, 1916, are especially pertinent to the genera discussed in this paper.

Ordovician starfish of North America are chiefly from the Cincinnatian shales of Ohio, the Richmond formation of Indiana and Ohio, and the Black River beds of Minnesota. The formations in the vicinity of Ottawa and Toronto, Canada, have also yielded several specimens. None have hitherto been recorded from the Ordovician section of Wisconsin.

SYSTEMATIC DESCRIPTIONS

Family HUDSONASTERIDAE Schuchert

Genus HUDSONASTER Sturtz

HUDSONASTER NARRAWAYI (Hudson) var. MACKVILLENSIS Jones, n. var.

Plate 70, figures 13, 14

Rays short, gradually tapering to obtusely angular extremities; highly flexed. Medial column of prominent subsequent radials, bounded on each side by one column of subsequent supramarginals and one of inframarginals, totalling five columns of plates on each row. Second row of inframarginals indicated on two rays.

Central disk plate surrounded by circle of five accessory plates. Madrepore plate almost obscure, pentagonal outline, slightly curved margin; smooth, small elevation in center; lies in interaxial position between accessory plates.

Measurements as follows:

Outside diameter of specimen	13–14 mm.
Length of single ray	8 mm.
Width of ray at base	4 mm.
Width of ray at mid-length	3 mm.
Diameter of central disk	6 mm.

Discussion.—The specimen presents only the dorsal surface, making generic identification a little doubtful. On the basis of the size, position, and unique structure of the madrepore plate, and the flexed arms, this form is considered a variety of *Hudsonaster narrawayi* (Hudson) (2, 3, 4).

The generic assignment of the species *narrawayi* is not settled. Spencer considers the species to be identical with *Paleaster caractaci* Gregory (6*a*). Schuchert places the species in the genus *Hudsonaster*, but states that the ambulacral plates are large, rectangular, not shaped as in other species of the genus. Spencer states:

> It is very clear that the systematic position of the form is not settled. The good specimens show only the oral sides. The specimens from St. Paul, Minn., placed by Schuchert in the species, are much smaller than the holotype described by Hudson, and have different proportions of the major and minor radius (6*b*).

Occurrence.—The holotype of the variety *mackvillensis* was found at the Jarchow Quarry, Mackville, Wisconsin, in April, 1926. The specimen is unusual in its perfect preservation in massive highly crystallized, dolomitic limestone. It is well weathered from the matrix.

The discovery of the specimen was briefly mentioned in abstract by Rufus M. Bagg (1) in 1927, but no published description has hitherto been made.

Holotype.—Lawrence Coll. Mus. 211 (Pl. 70. figs. 13, 14).

Family PROMOPALAEASTERIDAE Gregory

Subfamily PROMOPALAEASTERINAE Schuchert

Genus PROMOPALAEASTER Schuchert

PROMOPALAEASTER WISCONSINENSIS Jones, n. sp.

Plate 70, figure 15

Rays long, tapering gradually, slightly flexed, quite convex. Terminals truncated, slightly bulbous. Arms covered with rounded tubercles, angular in outline. Tubercles near central disk have pentagonal margin. Longitudinal section of ray includes 18 to 20 tubercles; transversely at mid length 8 or 9 rows of tubercles, narrowing to only 5 rows at end of ray. General oblique arrangement pronounced on each arm, especially at distal end.

Specimen fairly large; measurements as follows:

Outside diameter of specimen	53 mm. (2.1 ins.)
Length of single ray	27 mm.
Width of ray at base	11 mm.
Width of ray at mid length	6 mm.
Diameter of central disk	20 mm.

Discussion.—Like *Hudsonaster*, this specimen exhibits only the dorsal surface. One ray is crushed and partially concealed by a large brachiopod, *Hebertella occidentalis*.

Promopalaeaster is restricted to the Upper and Middle Ordovician of North America and is the largest and chief starfish of these formations. Only ten species of this genus have been described.

The specimen presents marked differences in comparison with other species of the genus. It is smaller than *P. wilsoni* and does not have as many triangular tubercles. There is no evidence of spines or anything to indicate their former existence such as several species present. The arrangement of the tubercles on this specimen resembles slightly that of *P. magnificus*, but these are smaller and fewer.

On the basis of the size, the distribution and shape of the tubercles, and proportional differences this starfish is considered a new species, *Promopalaeaster wisconsinensis*.

Occurrence.—This starfish was discovered in the Richmond formation at Bay Settlement, above Green Bay, Wisconsin, in April, 1927. The specimen is preserved in a shaly limestone layer with the surface fairly well weathered from the matrix.

Holotype.—Lawrence Coll. Mus. 212 (Pl. 70, fig. 15).

REFERENCES

1. Bagg, R. M., Fossil starfishes in the Galena limestone of Wisconsin: *Geol. Soc. Am. Bull.*, vol. 38, no. 1, p. 227, 1927.
2. Hudson, G. H., A fossil starfish with ambulacral covering plates (*Protopalaeaster narrawayi*, Ordovician, Ottawa, Canada): *Ottawa Nat.*, vol. 26, pp. 22–26, 45–52, 1912.
3. —— Does the type of *Protopalaeaster narrawayi* present an oral or aboral aspect?: *Ottawa Nat.*, vol. 27, pp. 77–84, 1913.
4. Raymond, P. E., On the nature of the so-called "covering plates" in *Protopalaeaster narrawayi: Ottawa Nat.*, vol. 26, pp. 105–107, 1912.
5. Schuchert, Charles, Revision of the Paleozoic Stelleroidea: *U. S. Nat. Mus., Bull.* 88, 1915.
6. Spencer, W. K., A monograph of the British Paleozoic Asterozoa: *Paleontogr. Soc. London, Mon.*, pt. 1, vol. 67, pp. 1–56, Feb. 1914; pt. 2, vol. 69, pp. 57–108. Oct. 1916, (*a*), Pt. 1, p. 21. (*b*), Pt. 2, p. 77.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 7, PP. 596–620, PLS. 71–75, OCTOBER, 1935

THE CONODONT FAUNA OF THE DECORAH SHALE (ORDOVICIAN)

CLINTON R. STAUFFER
University of Minnesota, Minneapolis, Minnesota

ABSTRACT

This paper presents brief discussions of the stratigraphy of the Decorah shale; and of the systematic position of conodonts, concluding that it is still undetermined. A list of localities is given, and a conodont fauna of 70 species in 27 genera is described. Four genera and 32 species are new.

Conodonts in Paleozoic sediments assume much of the importance of the Foraminifera in later sediments. They may be used to identify horizons where megascopic fossils are poor or wanting. In well-drillings from the earlier horizons, especially from shaly beds, these minute fossils reach the surface in a good state of preservation and can be identified. It is of much importance, therefore, that new forms be illustrated and described.

Acknowledgments.—This contribution has been made possible through the research funds of the Graduate School, University of Minnesota. The manuscript was received by the editor of the Journal April 2, 1935.

THE DECORAH SHALE

The Decorah shale, an argillaceous blue to greenish shale with numerous intercalated beds and lenses of blue to gray limestone, is persistent throughout the southeastern part of Minnesota, often giving rise to springs at its upper surface and in the southern part of the state forming the bottom bed or floor of caves.

The type locality is at Decorah, Iowa. It is, however, better developed and more deserving of recognition as an independent geologic unit to the north, reaching its optimum development at St. Paul, where nearly 75 feet of shale and limestone belonging to this formation have been exposed. Southwest of Minnesota and Iowa a very similar shale is found in the Middle Ordovician, attaining a thickness of several hundred feet. This shale is encountered in deep wells as far distant as Kansas and Oklahoma (1), where it carries a fauna similar to that of the Decorah and is commonly referred to as the Decorah shale. Southeast from Minnesota, however, the Decorah shale gradually changes to limestone until, in southern Wisconsin and the adjacent region in Illinois, it becomes parts of the Platteville and Galena limestones respectively (2). In fact, the dividing line between these two formations in Wisconsin and Illinois lies within the Decorah shale, at the base of Winchell's *Ctenodonta* bed (3), which corresponds to the base

Correlation of the Decorah Shale

<table>
<tr><th colspan="2">Minnesota</th><th>Iowa</th><th>Illinois</th></tr>
<tr><td>Galena limestone</td><td>Stewartville dolomite
Prosser limestone</td><td>Galena limestone</td><td rowspan="4">Galena limestone</td></tr>
<tr><td rowspan="6">Decorah shale</td><td>Fucoid bed</td><td rowspan="2">Ion member</td></tr>
<tr><td>Chasmotopora bed</td></tr>
<tr><td>Ctenodonta bed</td><td>Guttenberg member</td></tr>
<tr><td>Rhinidictya bed</td><td rowspan="3">Spechts Ferry member</td><td rowspan="3">Platteville limestone</td></tr>
<tr><td>Stictoporella bed</td></tr>
<tr><td>Lingula bed</td></tr>
<tr><td colspan="2">Platteville limestone</td><td>Platteville limestone</td></tr>
<tr><td colspan="2">Glenwood beds</td><td>Glenwood beds</td><td>Glenwood beds</td></tr>
<tr><td colspan="2">St. Peter sandstone</td><td>St. Peter sandstone</td><td>St. Peter sandstone</td></tr>
</table>

of the Guttenberg member of Iowa as recently proposed by Marshall Kay (4). In the clay pit at the Twin City Brick Plant, St. Paul, one can find *Receptaculites oweni* extending downward into the *Ctenodonta* bed, nearly 30 feet below the level at which the Decorah-Galena contact is drawn. This seems to suggest the same relationship for the upper and lower parts of the Decorah shale in Minnesota as that proposed for Iowa.

In the typical development of the shale it is rather easily separated from the beds above and below by more or less important breaks in sedimentation, but more especially by its fauna. The base of the Decorah shale contains several layers of limestone which are slightly disconformable on the Platteville limestone (5). This contact was described by Sardeson as the third corrasion zone, at the base of his *Stictoporella* bed (6). The lower layer in contact with the Platteville is, however, a hard, ferruginous, blue to brown limestone characterized by common specimens of *Lingula elderi* that still stand in an upright position; this bed is commonly called the "*Lingula* bed" by the writer. The limestone layer just above the *Lingula* bed, but separated from it by four inches of modified bentonite, carries abundant trilobites and may be filled with *Zygospira nicolleti*. This condition is especially found in the vicinity of Faribault, Rochester, and Chatfield, Minnesota, and in the outcrops to the south. The top of the Decorah shale is marked by an oolitic, limonitic zone containing a few pebbles, and the upper surface is often blackened and pitted, a corrasion zone (7) somewhat similar to that at the base of the formation. Where this is difficult to locate, the approximate contact may often be found by locating the highest horizon of abundant fucoids

and the rather abrupt appearance of *Zygospira recurvirostris* in the basal Prosser (Galena) limestone. The relationships thus expressed may be summed up in the accompanying table, which is a modification of that by G. Marshall Kay (8). It is quite probable that the great thickness of shale penetrated in wells of Kansas and Oklahoma represents more than the Decorah shale. In fact some of the petroleum geologists of that region regard it as extending downward to include the Glenwood beds (9).

THE DECORAH CONODONT FAUNA

Although the Decorah shale contains a large megascopic fauna, and some beds may be crowded with fossils of various kinds, one could hardly say that the formation as a whole is abundantly fossiliferous. An outcrop is seldom found, however, which will not yield a few species sufficiently characteristic to suggest the portion of the formation exposed. In addition to the fauna usually listed, there is a rather large microfauna, in which conodonts are exceedingly important. Conodonts are rarely to be seen in a hand specimen, but a sample taken from nearly any portion of the formation will usually yield a few of these fossils by washing and concentrating processes. In some portions of the Decorah shale they are relatively abundant and contribute many species to the fauna.

SYSTEMATIC POSITION OF THE CONODONTS

Conodonts have been included in various divisions of the Animal Kingdom but their relationships are still quite unsatisfactorily determined. They apparently belong to an entirely extinct division of whatever group is their nearest kin, and thus even their connection with modern forms is obscure. It is quite probable that several types of teeth belonged to a single individual and that the forms representing a single species can only be determined after a large number of assemblages have been found and studied. This suggestion was first made by Hinde (10), who found a conodont assemblage in the Genesee shale at North Evans, New York. The probable truth of this suggestion is more clearly brought out by the conodont assemblages recently described by Hermann Schmidt (11) and by H. W. Scott (12). Schmidt regards conodonts as the denticulations on the gill and hyoid arches of certain primitive fishes, such as the Arthrodira (Placodermi). He illustrates a small fish-like form (13) which was found associated with conodonts in the siliceous shales of the Upper Carboniferous near Arnsberg, Germany. This he says "perhaps belongs to *Gnathodus integer* n. sp.," a conodont assemblage that he illustrates and describes from the same horizon. Unfortunately the head of the fish-like specimen has been destroyed by pyritization and hence it is impossible to find the teeth in place. The association of the fish-like form with actual specimens of the conodont named may therefore have no special significance, although, of course, the suggestion is of im-

portance and may lead to some additional discoveries in the same region. Schmidt says these conodont assemblages, of somewhat different teeth, belong to the same individual and he thinks the relationship of different conodont types could be shown clearly if the collector would keep specimens together and in their positions as occurring on the fossiliferous slab. This of course is impossible when the fossils are found only by washing and concentrating large quantities of loose material.

Scott seems very certain that the conodont assemblages indicate clearly that they are the jaws of some form of Vermes (14), possibly coordinate with the Polychaeta but having fundamental differences which may have led to their extinction.

Significant facts about conodonts are gradually accumulating and ultimately may lead to their satisfactory classification as well as show their true relationship to other groups of animals. Among these facts are the assemblages of several different types of teeth in what appears to be the remains of a single individual; rights and lefts in the same type of tooth, indicating that they belonged to a bilaterally symmetrical animal; the chemical composition of the teeth, more or less similar in all conodonts from all horizons; the fibrous structure of some conodonts and the lamellar or ivory-like structure in many others, both of which differ radically from the Polychaeta; the distinct evidence in many conodonts that the denticles are inserted into the base and are only secondarily a part of it; the attachment of the notched or hollowed base of many conodonts to skeletal parts that are not bone, but a material similar in composition to that of the teeth themselves; in the elongate shaft-like fragments of skeletal elements, crudely developed articulations and concentric lamellar structure similar to that in some teeth; and the frequent association of dermal plates, often distinctly ornamented and similar in composition to the teeth, with both teeth and skeletal fragments. When good specimens or even good fragments of all these are found in close proximity, or as an assemblage of the remains of one individual, a long step towards the reconstruction of the animal can be made. In the mean time differences of opinion in regard to the type of animal bearing these teeth are sure to exist and no amount of argument can settle the matter.

LOCALITIES

The localities and horizons at which conodonts have been found in the Decorah shale are listed below. The numbers alone are given in the systematic part of the paper.

1. Lindel Brick and Tile Company, Zumbrota, Minnesota; 3 feet above water level in bottom of clay pit, 20 feet below the oolite zone.
2. Same, 7½ feet above water level, 15½ feet below oolite zone.
3. Same, 12 feet above water level, 11 feet below oolite zone.
4. Same, 17½ feet above water level, 5½ feet below oolite zone.
5. Same, 23 feet above water level, the oolite zone.
6. Gunderson Brick and Tile Company, Zumbrota, Minnesota; 20 feet above water level in bottom of clay pit, 5 feet above base of the oolite zone.

7. Same, 31 feet above water level, 16 feet above base of oolite zone.
8. Kenyon, Minnesota; along creek north of town, near the slaughter house, and at bottom of outcrop; probably near middle of the formation.
9. Same, just above no. 8; probably in middle portion of formation.
10. Kenyon, Minnesota; along small tributary to North Branch Zumbro River, just below the railway culvert one mile east of Kenyon; probably in lower part of formation.
11. Kenyon, Minnesota; along North Branch Zumbro River at the Tourist Camp one-half mile west of Kenyon; at top of formation.
15. Lieb Quarry, Faribault, Minnesota; 5 feet above base of formation.
16. Same, 10 feet above base of formation.
17. Same, 15½ feet above base of formation.
19. Jaeger Quarry, Faribault, Minnesota; immediately above "marble layer," 1½ feet above base of formation.
22. Cannon Falls, Minnesota; along highway 52, 5 miles south of town; just above the "marble layer," 1 foot above base of formation.
23. Same, 16½ feet above base of formation.
24. Same, the oolitic layer 53½ feet above base of formation.
26. Guttenberg, Iowa; along highway 13 at the north edge of town; basal layer of formation (Spechts Ferry member).
27. Same, soft blue shale layer 8 inches above base of formation (Spechts Ferry member).
28. Same, olive green shale 1 to 4 feet above base of formation (Spechts Ferry member).
30. Same, olive shale 7½ to 8 feet above base of formation (top of Spechts Ferry member).
34. Spechts Ferry, Iowa; olive shale 6½ feet above base of formation (The Platteville limestone is 48 feet thick here and this sample is from the Spechts Ferry member, 54½ feet above top of Glenwood beds).
35. Ion, Iowa; shaly beds along creek SW. of village (upper part of Ion member).
37. Spring Grove, Minnesota; lower part of formation, along county road 2½ miles NW. of town.
40. Caledonia, Minnesota; along highway 44, 6½ miles SW. of town; from very basal one-inch layer of formation.
41. Decorah, Iowa; about 35 feet above Iowa River, 15 feet below Galena limestone, in west edge of town.
42. Decorah, Iowa; base of outcrop along highway 55, opposite C. R. Carrier's oil station at north edge of town.
43. Same, a little above base of outcrop.
47. Harmony, Minnesota; at country school 5 miles north of town along highway 52; from roadside about 30 feet above base of formation.
48. Fountain, Minnesota; 2 miles south along highway 52; from bentonite layer in lower part of formation.
49. Same, 1½ feet above bentonite layer.
51. Wykoff, Minnesota; NE. ¼ sec. 9, T. 103 N., R. 12 W., about one-half mile SW. of old town of Fillmore, Fillmore, County; from bottom of outcrop which probably belongs in upper part of formation.
52. Fountain, Minnesota; 3 miles SE. of town (sec. 13, T. 103 N., R. 11 W.); from typical blue shale, probably lower part of formation.
55. Wykoff, Minnesota; Decorah shale, along

EXPLANATION OF PLATE 71

FIGS. 1, 3, 6, 7, 9–13, 15, 21—*Ozarkodina robusta* Stauffer, n. sp. 3, 7, loc. 94; 12, loc. 96; syntypes. 1, 6, 9–11, 13, 21, loc. 94; 15, loc. 96; paratypes. All ×30 except fig. 6, ×45. (p. 612)

2, 4, 5, 8, 14, 17–19, 22, 26—*Ozarkodina concinna* Stauffer. 2, 5, 8, 14, 17, 18, 22, 26, loc. 94; 4, 19, loc. 96. All ×30 except fig. 8, ×35. (p. 611)

16, 24—*Ozarkodina pauperata* Stauffer, n. sp., syntypes, ×35. 16, loc. 48; 24, loc. 67. (p. 611)

20, 27, 39, 41, 47—*Trichognathus recurvus* Branson and Mehl, ×30. 20, loc. 16; 27, loc. 15; 39, 41, loc. 40; 47, loc. 52. (p. 619)

28, 43—*Trichognathus gyroides* Stauffer, n. sp. 28, holotype, ×30, loc. 70; 43, paratype, ×35, loc. 67. (p. 619)

37—*Trichognathus illustris* Stauffer, ×30, loc. 57. (p. 619)

45, 50—*Trichognathus minnesotensis* Stauffer, n. sp., syntypes, ×30. 45, loc. 16; 50, loc. 15. (p. 619)

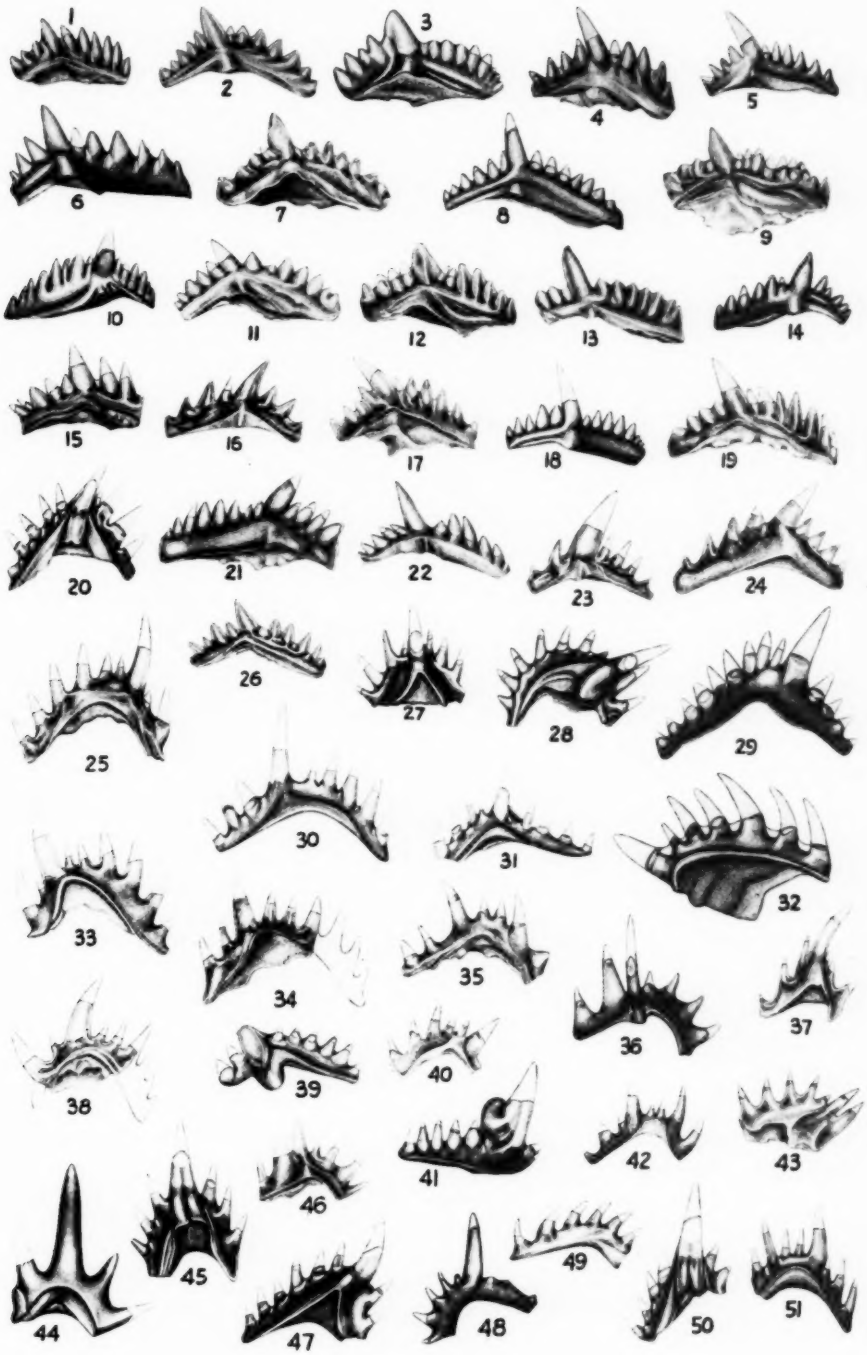
46—*Trichognathus deformis* Stauffer?, ×30, loc. 96. (p. 619)

23—*Dichognathus typicus* Branson and Mehl, ×35, loc. 67. (p. 604)

25, 29–35, 38, 40, 42, 49, 51—*Gyrognathus primus* Stauffer. 25, loc. 94; 29, loc. 40; 30, 31, 51, loc. 16; 32–35, 49, loc. 94; 38, loc. 67; 40, loc. 57; 42, loc. 37. All ×30 excep figs. 32, 34, 38, ×35. (p. 606)

36, 48—*Gyrognathus planus* Stauffer, n. sp., syntypes, ×35, loc. 94. (p. 606)

44—*Polycaulodus chatfieldensis* Stauffer, n. sp., holotype, ×30, loc. 62. (p. 613)



Stauffer, Ordovician Conodonts

county highway 2½ miles north of town, from lower part of formation; 33 feet above top of Glenwood beds.
56. Same, 5 feet above no. 55; 38½ feet above top of Glenwood beds.
57. Same, upper part of formation; 62 feet above top of Glenwood beds.
61. Chatfield, Minnesota; at the Water Works hill, Troy road; 3½ feet above base of formation.
62. Chatfield, Minnesota; along state highway 74, 2 miles west of town, from oolitic layer at the spring, probably upper part of formation.
63. Chatfield, Minnesota; along highway 52, 6 miles NW. of town; from oolitic layers 41 feet above base of formation.
64. Same, 52½ feet above base of formation.
65. Same, 56 feet above base of formation.
66. Same, 65 feet above base of formation.
67. Same, 34½ feet above base of formation.
68. Same, 77½ feet above base of formation.
69. Same, 2 feet above base of formation.
70. Same, 3½ feet above base of formation.
71. Same, 9 feet above base of formation.
74. Fountain, Minnesota; along highway 52, 2 miles north of town; 1 foot above base of formation.
75. Same, 2½ feet above base of formation.
76. Same, 30 feet above base of formation and just below iron stained oolitic bed.
78. Eyota, Minnesota; along highway 14, 2½ miles east of town; 6 feet below base of oolite bed (Spechts Ferry member).
79. Dover, Minnesota; along highway 14, one mile west of town; 18 feet above base of formation.
85. Wykoff, Minnesota; along Prosser Creek, at the spring, probably top of formation.
86. Mabel, Minnesota; along highway 44, 4¼ miles east of town; lower part of formation, 3 feet above Plateville limestone.
87. Viola, Minnesota, at school house one-quarter mile west of town; 2½ to 3 feet above base of formation.
88. Viola, Minnesota; on Mr. Richardson's farm one-half mile NW. of town; 10 feet above base of formation.
89. Rochester, Minnesota; along highway 59, 3 miles north of town; about 15 feet above base of formation.
91. Rochester, Minnesota; along highway 14, 3½ miles west of town; 28 feet above base of formation.
92. Same, 31 feet above base of formation.
93. Roscoe, Minnesota; 1.7 miles south of town; about 30 feet above base of formation.
94. Ford Bridge, Minneapolis, Minnesota; Mississippi River bluff; 4½ feet above base of formation.
95. St. Paul, Minnesota; manhole to sewer at National Biscuit Company, University Avenue; loose material probably 30 feet above base of formation.
96. Minneapolis, Minnesota; campus of University of Minnesota; lower portion of formation.

SYSTEMATIC DESCRIPTIONS

Genus ACONTIODUS Pander, 1856

Acontiodus PANDER, *1856*, Monographie der fossilen Fische des silurischen Systems der russich-baltischen Gouvernements, p. 30, St. Petersburg.

There are three forms left among the simple teeth which seem to be scarce. Although they do not coincide exactly and later may have to be separated, they are being described under one general name. Their main characteristic is a relatively strong development of the concave edge of the tooth, which instead of being keel-like and sharp pointed, forms an even or more or less concave surface which is either smooth . . . or is equipped with a sharply protruding keel in the center. . . . The two lateral faces join on the convex edge, and either grade into one another in a circular form without being separated by a keel . . . or grade into one another at a certain acute or nearly right angle. [Translation.]

ACONTIODUS ALVEOLARIS Stauffer, n. sp.

Plate 74, figure 44

Holotype:—Geol. Mus. Univ. Minnesota, B4677.

Base not expanded beyond edges of cusp, slightly excavated; type has a portion of skeletal material still sticking in the cavity. Cusp curved inward, smooth on convex portion of the curve, but with a median groove on the ridge-like portion of the inside and rather deep furrows adjacent to the lateral keeled edges; cross-section of cusp thus broadly rounded on outer side but with two symmetrical sigmoid curves uniting in the median furrow. As they approach the base, lateral keels spread outward slightly to increase the lateral extent of base. Median portion of outer side ends at base in

prominent rounded knob with slight depressions on either side.

Horizon and locality.—40.

Genus ANCYROGNATHUS Branson and Mehl, 1933

Ancyrognathus BRANSON and MEHL, *1933*, Univ. Missouri Studies, vol. 8, p. 240.

ANCYROGNATHUS? sp. *a*

Plate 75, figure 24

Figured specimen: Geol. Mus. Univ. Minnesota, B4707.

A small fragment of a denticulated plate; under side excavated at one end; two ridges running diagonally from corners adjacent to excavation, nearly meeting at central line; from this point continuing as margins of a central groove. Upper surface plain except for the two denticulated ridges converging from the corners; where ridges unite they probably extended downward as a single dental ridge.

Horizon and locality.—40.

ANCYROGNATHUS? sp. *b*

Plate 75, figures 60, 61

Figured specimens: Geol. Mus. Univ. Minnesota, B4740.

A fragmentary specimen which probably belongs to some related genus, consisting of an elongate plate that bifurcates near posterior and terminates in rounded lobes. Under side smooth except for median keel that bifurcates with plate; a branch follows each lobe. Upper surface marked by bifurcating groove immediately above keel, a raised nodose border and by an irregular row of denticular nodes which bound the notch or bifurcation of the plate-like base. In center, near broken end, a larger angular node or denticle, probably beginning of a series extending towards the anterior? end.

Horizon and locality.—40.

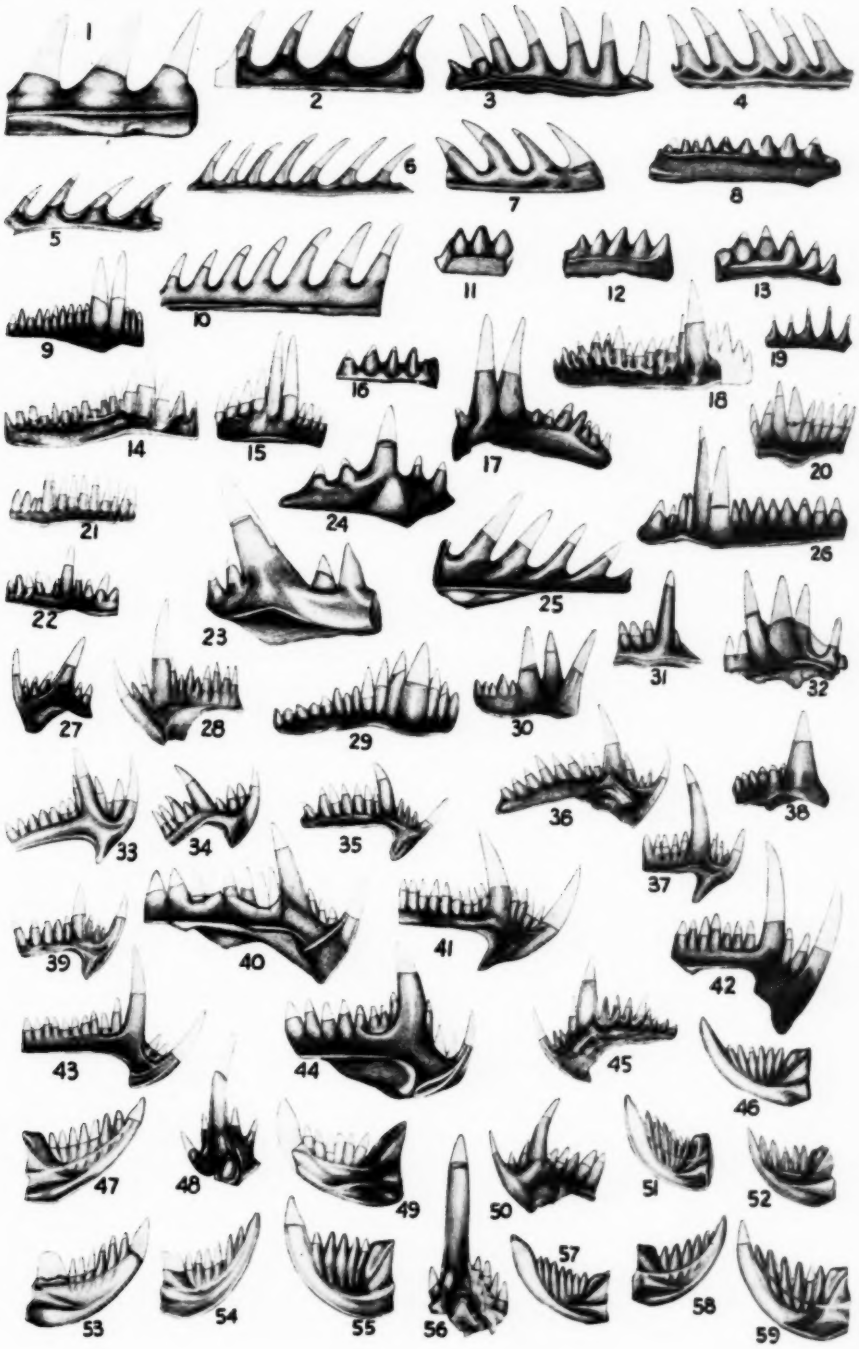
Genus BARBARODINA Stauffer, n. gen.

Base sheath-like, with basal cavity starting as a groove at the posterior end

---

EXPLANATION OF PLATE 72

FIGS. 1—*Neocoleodus spicatus* Branson and Mehl?, ×35, loc. 94. (p. 608)
13—*Neocoleodus breviconus* Branson and Mehl, ×30, loc. 95. (p. 608)
2, 4–7, 10, 25—*Lonchodus spinuliferus* Stauffer. 2, 5, loc. 48; 4, 6, 10, 25, loc. 94; 7, loc. 95. Figs. 2, 5, 10, ×35; fig. 25, ×60; others, ×30. (p. 607)
19—*Lonchodus* sp. *a*, ×30, loc. 95. (p. 608)
3—*Lonchodus?* sp. *b*, ×35, loc. 94. (p. 608)
8, 11, 12, 16—*Polyplacognathus?* sp. *b*, ×30, loc. 40. (p. 616)
9, 14, 15, 18, 20, 26, 29, 32—*Heterognathus idoneus* Stauffer, n. gen. and sp. 14, 18, syntypes, loc. 48. 9, 15, 20, 26, 32, loc. 94; 29, loc. 96; paratypes. All ×35 except figs. 20, 29, ×30. (p. 607)
17, 30—*Heterognathus brevis* Stauffer, n. gen. and sp., ×35, loc. 94. 17, holotype; 30, paratype. (p. 607)
21, 22, 31—*Heterognathus simplex* Stauffer, n. gen. and sp., paratypes, ×30. 21, 31, loc. 94; 22, loc. 95. (p. 607)
23—*Euprioniodina dubia* Stauffer, n. sp., holotype, ×35, loc. 94. (p. 605)
24—*Gyrognathus primus* Stauffer, ×30. loc. 94. (p. 606)
27, 28, 33–37, 39–45, 50—*Phragmodus cognitus* Stauffer. 27, loc. 95; 28, 34, loc. 96; 33, 35, 37, 39–44, loc. 94; 36, 45, loc. 48; 50, loc. 57. Figs. 36, 42, 43, 45, ×35; figs. 40, 44, ×60; others, ×30. (p. 613)
38—*Prioniodus liratus* Stauffer, ×35, loc. 94. (p. 603)
46, 47, 49, 53, 54, 57—*Belodus grandis* Stauffer, n. sp. 46, loc. 67; 47, loc. 57; syntypes. 49, loc. 94; 53, loc. 37; 54, loc. 57; 57, loc. 62; paratypes. All ×35 except figs. 53, 57, ×30. (p. 603)
51, 52, 55, 58, 59—*Belodus wykoffensis* Stauffer, n. sp. 52, loc. 67; 58, loc. 57; syntypes. 51, 55, 59, loc. 57, paratypes. All ×35 except fig. 51, ×30. (p. 604)
48, 56—*Trichognathus recurvus* Branson and Mehl. 48, loc. 57, ×35; 56, loc. 94, ×30. (p. 619)



Stauffer, Ordovician Conodonts

and widening out into a broad deep cavity beneath the cusp. Denticles thin, discrete, curving inward; cusp highly curved, pointed, but base much thickened, passing into sides of sheath at base; a cross-section of cusp shows an outer and an inner rounded face, with inner face most convex, its edges failing to meet those of the outer curvature; the gap bridged by a flattened surface which passes into the keeled edge.

Genotype: *Barbarodina typicala* Stauffer, n. sp.

BARBARODINA GRANDIS
Stauffer, n. sp.
Plate 73, figures 6, 8

Syntypes: Geol. Mus. Univ. Minnesota, B4580, B4582.

Base or bar thick, tapering gradually to posterior; Under side with broad excavation which begins at the posterior end, extends forward, widens into the cavity beneath the cusp, extends downward into tapering sub-basal projection of cusp. A highly arched plate forms upper boundary of cavity, extends from dental bar to sub-basal portion of cusp; 4 to 6, possibly more, subequal denticles extending along the bar, inclined slightly to posterior. Cusp moderately to strongly curved, sharply keeled along inner edge.

Horizon and localities.—37, 94.

BARBARODINA TYPICALA Stauffer, n. sp.
Plate 73, figures 4, 5

Syntypes: Geol. Mus. Univ. Minnesota, B4578, B4579.

Base sheath-like, having long slender, straight or slightly curved bar that is excavated throughout its entire length; margins of excavation, or sub-basal furrow, increase in importance, flare outward towards anterior end, where excavation becomes deep, broad cavity beneath cusp. Denticulated edge bears 5 or 6, possibly more, laterally flattened, slender, inwardly curving discrete denticles. Cusp relatively large, slender, set much out of line with denticles, its inner keel forming inner edge of the basal cavity.

Horizon and localities.—48; 67, 70, 71, 86, 89.

Genus BELODUS Pander, 1856

Belodus PANDER, *1856*, Monographie der fossilen Fische des silurischen Systems der russich-baltischen Gouvernements, p. 30, St. Petersburg.

From a long base there rises a rather high tooth or cusp which gradually changes from an almost horizontal position through a highly arched curve to a slender tapering upright point. A rather prominent carina extends along the middle of the lateral faces from the base to half the height of the tooth, and several small, sharp-pointed denticles are attached to its concave edge up to one-third of its height where the tooth is still rather wide. [Translation.]

BELODUS GRANDIS Stauffer, n. sp.
Plate 72, figures 46, 47, 49, 53, 54, 57

Types: Geol. Mus. Univ. Minnesota, syntypes, B4561, B4562; paratypes, B4564, B4568, B4569, B4572.

Base and whole unit flat on inner side but with abrupt off-set below mid-line of denticles and a marginal ridge or rim on outer side; rim spirally striated on better preserved specimens. Base fairly uniformly curved, tapering to a point; near proximal end, however, an abrupt change in curvature.

Between expanded heel-like portion of base and distal end a series of 6 or 7, possibly more, similar, crowded or wedged-in denticles which penetrate deep into base and emerge with confluent edges. There is good evidence in this species, to indicate that, as the dental unit grows, these denticles are added by emerging from both heel and tip to take their places in the series; in fact, some may be seen in process of formation and of emerging.

Proximal end excavated in form of two flattened cones which become more or less confluent in some specimens; lower conical excavation penetrates deep into bar

as a thread-like extension curving at the tip to follow curvature of base.

Horizon and localities.—37, 57, 62, 67, 94; 17, 26, 40, 43, 48, 76, 78, 86.

BELODUS WYKOFFENSIS Stauffer, n. sp.
Plate 72, figures 51, 52, 55, 58, 59

Types: Geol. Mus. Univ Minnesota, syntypes, B4567, B4573; paratypes, B4566, B4570, B4574.

Base thin, nearly flat on both sides, although with slight off-set below mid-dental line on outer side. Except for abrupt change in curvature near proximal end, base regularly curved, tapering to a point at distal end; proximal end expanded on upper side into smooth heel; between heel and tip of base 5 or 6, possibly more, sub-equal denticles crowded or wedged into upper side of bar.

Excavation limited to proximal end, in form of two flattened conical cavities almost completely separated from each other; lower extends into base nearly half its length.

Horizon and localities.—57, 67; 37, 76.

Genus CYRTONIODUS Stauffer, 1935

Cyrtoniodus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 140.

CYRTONIODUS APICALIS Stauffer, n. sp.
Plate 73, figures 1, 10, 43, 45

Types: Geol. Mus. Univ. Minnesota, holotype, B4575; paratypes, B4584, B4617, B4619.

Base relatively thin, slender, arched upward, tapering to posterior; entire length of under side with broad furrow that deepens and flares slightly into a wide pocket towards anterior. Cusp large, laterally compressed, with sharply keeled edges; 9 to 12 or more elongate, slender, laterally compressed, crowded denticles follow the cusp and with it form a laterally arched dental edge from which all the units curve slightly inward; denticles increase slightly in length from anterior to second or third, then decrease to posterior extremity.

Horizon and localities.—48, 94.

CYRTONIODUS COMPLICATUS Stauffer, 1935
Plate 73, figures 9, 11–13, 15, 16, 18–20, 25, 27, 32, 38, 41, 42, 47

Cyrtoniodus complicatus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 140, pl. 11, figs. 44, 46, 48–51.

Figured specimens: Geol. Mus. Univ. Minnesota, B4583, B4585–B4587, B4589, B4590, B4592–B4594, B4599, B4601, B4606, B4612, B4615, B4616, B4621.

Observation.—This is a very common species in the Decorah shale at some localities. In the more typical form the cusp tends to curve into parallelism with the denticles. In the others the cusp is longer, straighter, and fails to approach very closely to parallelism. Despite the variation these forms seem to grade into each other and are regarded as belonging to the same species.

Horizon and localities.—48, 94, 96; 10, 15, 16, 26, 28, 37, 40, 49, 51, 52, 61, 68, 69, 71, 74, 86, 89.

Genus DICHOGNATHUS Branson and Mehl, 1933

Dichognathus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 35.

DICHOGNATHUS TYPICUS Branson and Mehl, 1933
Plate 71, figure 23

Dichognathus typicus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 113, pl. 9, figs. 27–29.

Figured specimen: Geol. Mus. Univ. Minnesota, B4487.

Observation.—Although widely distributed, this is not a common fossil in the Decorah shale. Most specimens are delicate, but seem to have all the essential characteristics of the species.

Horizon and locality.—64; 1, 8, 9, 15, 17, 22, 30, 37, 40, 43, 47, 48, 67, 70, 74, 77, 86, 91, 94.

DICHOGNATHUS VARIABILIS Stauffer, n. sp.
Plate 73, figures 14, 24, 30, 31, 34–37, 40, 44, 50, 59; Plate 75, figure 8

Types: Geol. Mus. Univ. Minnesota, syntypes, B4598, B4618; paratypes, B4588, B4604, B4605, B4608–4611, B-4614, B4624, B4633, B4691,

Base triangular, posterior and interior limbs meeting at an angle less than 90°. Basal excavation begins at the extremities of the anterior and interior limbs, widens and deepens as it approaches the apical angle where it forms a deep cavity beneath posterior portion of cusp; its flaring edges form an arched plate between principal limbs. Cusp at junction of posterior and interior limbs, stout, moderately elongate, triangular in cross-section; each of angles of cross-section corresponds to a limb of base and forms a keel of which the anterior and posterior are pronounced throughout length of cusp.

Anterior limb is formed by downward projection of cusp, smooth, not excavated; posterior limb bears 7 or more sub-equal denticles; interior limb almost smooth, crenulate or bears a few small, nearly obsolete denticles; this interior limb passes into and becomes confluent with inner keel of cusp.

Horizon and localities.—37, 94; 1, 6, 7, 15, 16, 24, 35, 40, 48, 49, 51, 52, 61, 67, 69, 70, 75, 86, 89, 95, 96.

DICHOGNATHUS? sp.
Plate 75, figure 10

Figured specimen: Geol. Mus. Univ. Minnesota, B4693.

Base apparently consisting of two bars meeting at a little less than 90°; angular space between bars bridged by highly arching plates that enclose a wide, deep cavity extending into base of cusp. Cusp short, stout, tapering gradually for about two-thirds its length, then rapidly to a sharp point. Lateral edges keeled, with one or two small, secondary keels on posterior side. Lateral bar fragmentary but probably smooth; posterior bar much more important, still preserving remnants of two denticles; there may have been more.

Horizon and locality.—94.

Genus DISTACODUS Hinde, 1879

Machairodus PANDER, *1856*, Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements, p. 22 (not *Machairodus* Kaup).

Distacodus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, p. 357.

Differently bent teeth are included under this name; both convex lateral faces grade into a more or less sharp-edged carina. With that type which comes closest to the Drepanodae, the cross-section is rhombic with four even faces; with the other types, the carinae protrude sharply from the lateral faces. Although both lateral faces of many forms are not symmetrical and although the carina of one side often is sharp and narrow and that of the other side dull and broad, this does not seem sufficient reason for separating them. (Translated from Pander.)

DISTACODUS FALCATUS Stauffer, 1935
Plate 74, figure 30

Distacodus falcatus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 142, pl. 12, fig. 16.

Figured specimen: Geol. Mus. Univ. Minnesota, B4663.

Observation.—Base very slightly larger than the bottom of cusp, with a conical excavation on under side still filled with skeletal tissue; bent at right angles below the middle; lateral edges with weakly developed keels. This specimen appears to be almost symmetrical about the plane in which it is bent.

Horizon and locality.—40; 10, 37, 64.

Genus EUPRIONIODINA Ulrich and Bassler, 1926

Euprioniodina ULRICH and BASSLER, *1926*, U. S. Nat. Mus., Proc., vol. 68, p. 29.

EUPRIONIODINA DUBIA Stauffer, n. sp.
Plate 72, figure 23

Holotype: Geol. Mus. Univ. Minnesota, B4538.

Base thick, slightly arched; excavation on under side narrow and shallow near the extremities but expanding into a wide, deep cavity beneath cusp. Cusp thick at base, with sharp keeled edges, inclined or deflected so as nearly to parallel denticles of posterior limb of base; both limbs fragmentary, each still retaining two denticles, but there probably were more; those on anterior limb larger, usually discrete; on posterior

limb, somewhat crowded, first one partly confluent with cusp.

Horizon and locality.—94.

Genus GYROGNATHUS Stauffer, 1935

Gyrognathus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 144.

GYROGNATHUS PLANUS Stauffer, n. sp.
Plate 71, figures 36, 48

Syntypes: Geol. Mus. Univ. Minnesota, B4500, B4512.

Base composed of two flattened limbs, one of which is thin, relatively short, nearly straight; the other thick, highly arched; the two meet in a rounded arch. Under side of base excavated deeply throughout the length of limbs, forming a deep pit or cavity beneath center of arch; curved limb bears 5 or more small, slender, inward-curving denticles; the straight limb bears 2 or possibly 3 larger denticles curving in the same manner as the others. Cusp large, laterally flattened, set at right angles to the denticles on the straight limb; base of cusp curved sharply, rising above the other limbs to form a kind of third limb.

Horizon and locality.—94.

GYROGNATHUS PRIMUS Stauffer, 1935
Plate 71, figures 25, 29, 30–35, 38, 40, 42, 49, 51; Plate 72, figure 24

Gyrognathus primus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 144, pl. 12, figs. 8, 9

Figured specimens: Geol. Mus. Univ. Minnesota, B4489, B4493–4499, B4502, B4504, B4506, B4513, B4515, B4539.

Observation.—This species is common in the Decorah shale. It is somewhat variable but still retains its general characters sufficiently to be identified. There are usually two small denticles on one side of the cusp and one small denticle on the other, but they may be broken and their bases easily overlooked. Although some of the specimens are very good it is still undertain which is the anterior end. Figures 25 and 33 are probably typical.

Horizon and localities.—15, 16, 37, 57, 64, 94; 5, 24, 26, 40, 48, 49, 52, 61, 67, 70, 76, 86, 89, 95, 96.

Genus HETEROGNATHUS Stauffer n. gen.

Base thin, long, slender, straight or slightly arched and twisted just anterior to the middle; under side of base with narrow groove extending entire length, slightly widening and deepening beneath the arch or beneath the more prominent denticles; the upper edge of base bears 2, 3, or 5, possibly more, large, long, pointed, orally flattened, aborally

EXPLANATION OF PLATE 73

FIGS. 1, 10, 43, 45—*Cyrtoniodus apicalis* Stauffer, n. sp. ×35. 1, loc. 48, holotype. 10, loc. 48; 43, 45, loc. 94; paratypes. (p. 604)

9, 11–13, 15, 16, 18–20, 25, 27, 32, 38, 41, 42, 47—*Cyrtoniodus complicatus* Stauffer. 9, 18, 19, loc. 37; 11–13, 15, 16, 20, 25, 27, 38, 41, 42, 47, loc. 94; 32, loc. 96. Figs. 13, 20, 25, 41, 42, ×35; others, ×30. (p. 604)

2, 3, 17, 22, 26—*Subcordylodus? inaequalis* Stauffer, n. sp. 2, 26, loc. 48; 3, loc. 94; syntypes. 17, loc. 94; 22, loc. 48; paratypes. Figs. 3, 17, ×30; others, ×35. (p. 618)

7, 23, 28, 29, 33, 39—*Subcordylodus rectilineatus* Stauffer. 7, loc. 67; 23, 29, 33, 39, loc. 94; 28, loc. 52. Figs. 7, 23, 33, ×35; others, ×30. (p. 618)

21—*Subcordylodus* sp., ×30, loc. 94. (p. 618)

4, 5—*Barbarodina typicala* Stauffer, n. gen. and sp., syntypes, ×35, loc. 48. (p. 603)

6, 8—*Barbarodina grandis* Stauffer, n. gen. and sp., syntypes, ×30. 6, loc. 37; 8, loc. 94. (p. 603)

14, 24, 30, 31, 34–37, 40, 44, 50, 59—*Dichognathus variabilis* Stauffer, n. sp. 24, loc. 37; 44, loc. 94; syntypes. 14, 30, 31, 34–37, 40, 50, 59, loc. 94, paratypes. All ×30 except fig. 59, ×35. (p. 604)

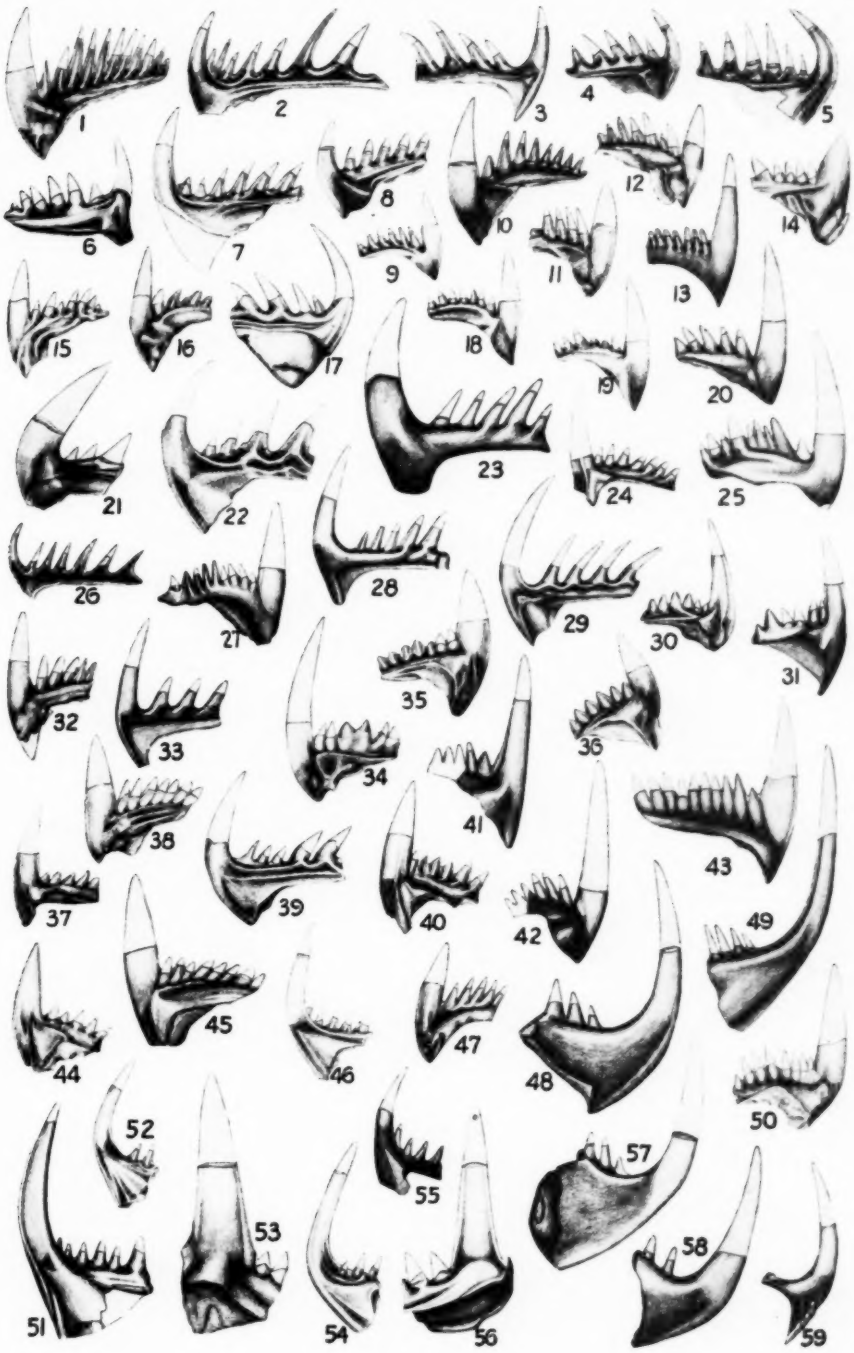
46, 52, 54—*Prioniodus aculeatus* Stauffer, ×30. 46, loc. 57; 52, 54, loc. 67. (p. 616)

48, 49, 57, 58—*Prioniodus cristulus* Stauffer, ×35, loc. 94. (p. 616)

51—*Plectodina dilata* Stauffer, ×30, loc. 47. (p. 613)

53, 56—*Microcoelodus obliquus* Stauffer, loc. 94. Fig. 53, ×35; fig. 56, ×30. (p. 608)

55—*Subprioniodus hamatus* Stauffer, ×30, loc. 95. (p. 618)



Stauffer, Ordovician Conodonts

rounded denticles on the arched or twisted portion; these may incline in various directions. Anterior limb or portion of base bears 4 or 5, possibly more, denticles of decreasing size; posterior limb bears 10 to 12, possibly more, small laterally flattened, sharp-pointed denticles, the edges of which may be partly confluent near base.

Genotype: *Heterognathus idoneus* Stauffer, n. sp.

HETEROGNATHUS BREVIS Stauffer, n. sp.
Plate 72, figures 17, 30

Types: Geol. Mus. Univ. Minnesota, holotype, B4532; paratype, B4545.

Base relatively thin, laterally curved, with shallow excavation on the under side that deepens beneath the larger of the anterior denticles. Posterior limb of base tapering, bearing 7 or 8 laterally flattened uneven denticles; anterior limb very short, bent downward, either plain or bearing a single denticle; 2 or 3 large, cusp-like denticles of nearly equal size occupying the highest and thickest part of base; These are much elongate, with cross-sections flattened on the inner and convex on the outer sides, and with their adjacent edges confluent near base.

Horizon and locality.—94; 48, 61.

HETEROGNATHUS IDONEUS Stauffer, n. sp.
Plate 72, figures 9, 14, 15, 18, 20, 26, 29, 32

Types: Geol. Mus. Univ. Minnesota, syntypes, B4529, B4533; paratypes, B4524, B4530, B4535, B4541, B4544, B4547.

Base thin, tapering to extremities, straight or slightly sinuous along middle of upper edge; lower side may be gently arched but usually straight, with a shallow groove which is slightly expanded beneath the larger denticles. Cusp-like denticles, occupying thickened and sinuous part of bar, consist of a group of 3 or 4, possibly more, which are similar elongate and may be inclined in various directions as the cutting edge makes a sigmoid curve. These larger denticles have flattened inner and rounded outer surfaces, giving a planoconvex cross-section; edges confluent near base.

Horizon and localities.—74, 94, 95, 96; 1, 27, 43, 48, 51, 70, 86.

HETEROGNATHUS SIMPLEX Stauffer, n. sp.
Plate 72, figures 21, 22, 31

Syntypes: Geol. Mus. Univ. Minnesota, B4536, B4537, B4546.

Base or bar thin, nearly straight along the lower margin, which has a narrow groove throughout its length; upper edge flexed outward in middle at cusp, which thus makes an angle of about 30° with inner edge. Cusp flattened on inner side, rounded on outer side, long and slender. Denticles laterally compressed; those next to cusp slightly inclined outward with cusp and may be somewhat enlarged; about 4 denticles anterior to the cusp, 6 or more posterior to it.

Horizon and locality.—94; 1, 2, 15–17, 19, 22, 27, 30, 37, 40, 48, 51, 55, 61–63, 69–71, 74, 75, 86, 89, 92, 95.

Genus LONCHODUS Pander, 1856

Lonchodus PANDER, *1856*, Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements, p. 32.

Very slender vertical, inclined or curved denticles which point in several different directions and which rise from a horizontal base. . . . Smaller denticles may occur between the larger ones. . . . The general characters of the genus may be given as slender pointed or lamellar denticles occurring as a uniform series or alternating with smaller denticles of varying size and number, all of which originate in a horizontal or convex base. [Translated.]

This genus evidently includes a number of fragments, the exact natures of which are not known because of their fragmentary condition.

LONCHODUS SPINULIFERUS Stauffer, 1932
Plate 72, figures 2, 4–7, 10, 25

Lonchodus spinuliferus STAUFFER, *1932*, Jour. Paleontology, vol. 6, p. 263, pl. 40, fig. 32.

Figured specimens: Geol. Mus. Univ. Minnesota, B4517, B4519–4522, B4525, B4540.

Observation.—A series of fragments, such as have been included in this species. One specimen (fig. 25), which shows the posterior terminus, indicates that the denticles incline and diminish in size towards that terminus. The bar also tapers and thins near the posterior end. Several of the specimens have skeletal fragments sticking in the basal groove. The anterior extremity of these specimens is still unknown and the exact classification undetermined.

Horizon and localities.—48, 94–96; 4, 6, 7, 9, 17, 23, 24, 27, 37, 52, 57, 61, 62, 67, 70, 76, 77, 79, 86, 92.

LONCHODUS sp. *a*
Plate 72, figure 19

Figured specimen: Geol. Mus. Univ. Minnesota, B4534.

Observation.—A fragment with very slender, discrete vertical denticles on a slender nearly straight bar.

Horizon and locality.—95.

LONCHODUS? sp. *b*
Plate 72, figure 3

Figured specimen: Geol. Mus. Univ. Minnesota, B4518.

Base broad, tapering to posterior, slightly curved along inner side; under side broadly excavated, still partly filled with skeletal tissue. Upper edge of base bearing a series of laterally flattened denticles, which increase in size and diminish in inclination from posterior. Anterior broken, its character unknown.

Horizon and locality.—94.

Genus MICROCOELODUS Branson and Mehl, 1933

Microcoelodus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 89.

MICROCOELODUS OBLIQUUS (Stauffer, 1930)
Plate 73, figures 53, 56

Prioniodus? obliquus STAUFFER, *1930*, Jour. Paleontology, vol. 4, p. 123, pl. 10, figs. 3, 4.

Figured specimens: Geol. Mus. Univ. Minnesota, B4627, B4630.

Observation.—Base with a wide excavation which becomes deep beneath the cusp. There are apparently several small denticles on either side of the cusp; the latter is flattened on the inner side and shows some axial lines perhaps connected with development.

Horizon and locality.—94; 6–8, 86.

MICROCOELODUS sp.
Plate 74, figure 24

Figured specimen: Geol. Mus. Univ. Minnesota, B4657.

Base arched, with a wide and deep excavation on the under side. A cusp of medium size rises from the highest portion of the upper side of the base, and there appear to have been several denticles on either side, but this is not very clear. The specimen is quite fragmentary.

Horizon and locality.—94.

Genus NEOCOLEODUS Branson and Mehl, 1933

Neocoleodus BRANSON and MEHL, *1933*, Univ Missouri, Studies, vol. 8, p. 24.

NEOCOLEODUS BREVICONUS Branson and Mehl, 1933?
Plate 72, figure 13

Neocoleodus breviconus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 24, 25, pl. 1, figs. 1–3.

Figured specimen: Geol. Mus. Univ. Minnesota, B4528.

Observation.—Bar thick, shallow, tapering to posterior; anterior broken; under side nearly straight and with a broad shallow groove; upper edge curves and bears a half dozen or more short, stout, laterally compressed, closely set denticles, with confluent edges at the base.

Horizon and locality.—95.

NEOCOLEODUS SPICATUS Branson and Mehl, 1933?
Plate 72, figure 1

Neocoleodus spicatus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 24, pl. 1, fig. 37.

Figured specimen: Geol. Mus. Univ. Minnesota, B4516.

Observation.—Three similar stout denticles are preserved on a broad but relatively shallow bar. Both ends of the bar

are broken and there is no means of determining how many denticles were in the original series or how it terminates. The denticles are subcircular in cross-section with very slight development of the anterior-posterior keels; they are probably straight and are set at an angle of about 75° to the bar. The under side of the bar has a shallow groove in which a portion of the skeletal attachment still remains.

Horizon and locality.—94.

Genus OISTODUS Pander, 1856

Oistodus PANDER, *1856*, Monographie der fossilen Fische des silurischen systems der russisch-baltischen Gouvernements, p. 27.

A small subdivision is formed by those simple teeth which have a very broad, long and hollow base. Only one single genus is provisionally established from them since the character of the various forms is quite uniform. They are generally transparent, yellow, and of a horny appearance ,but contain lime. [Translated.]

OISTODUS ABUNDANS Branson and Mehl, 1933

Plate 75, figures 2, 7, 11–13, 19

Oistodus abundans BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 109, pl. 9, figs. 11, 17.

Figured specimens: Geol. Mus Univ. Minnesota, B4685, B4690, B4694–4696, B4702.

Base slightly extended to the posterior, compressed, keeled along the upper margin; a deep narrow excavation on under side, widest in center. Cusp laterally compressed, blade-like, keeled at both edges, slightly curved inward, the anterior keeled margin extending downward to meet anterior end of base in a sharp point.

Horizon and localities.—37, 40, 48, 67; 6, 8, 17, 43, 49, 57, 61, 65, 66, 75, 77, 79, 86, 87, 89, 92, 94.

OISTODUS BREVIS Stauffer, n. sp.

Plate 74, figure 32

Holotype: Geol. Mus. Univ. Minnesota, B4665.

Base extended slightly to posterior where it flares widely; Under side of base with very shallow excavation. Cusp short, stout, curving abruptly to posterior, laterally compressed but with a biconvex cross-section; anterior and posterior edges keeled but not very sharply.

Horizon and locality.—40; 17.

OISTODUS CURVATUS Branson and Mehl, 1933

Plate 74, figures 5, 10, 12, 17, 20–23, 25–29, 31, 33–40, 47–49

Oistodus curvatus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, pp. 110, 111, pl. 9, figs. 4, 10, 12.

Figured specimens: Geol. Mus. Univ. Minnesota, B4638, B4643, B4645, B4650, B4653–4656, B4658–4662, B4664, B4666–4673, B4680–4682.

Observation.—It seems probable that all of the specimens illustrated belong to the species indicated. Some of them, such as figures 23 and 27, are quite typical but others vary somewhat. Certain of the specimens have partly broken bases which have not been restored and hence that feature may not be sufficiently apparent from the illustrations. In general, however, the bases of these Decorah shale specimens seem to flare out more and to be larger than on the types. Some specimens are exceedingly thin and delicate while others are much more robust. Some curve more and have more of a lateral twist. None of these features seem sufficient to separate them from the types and a large series is given to bring out some of these differences. It is one of the abundant species in the Decorah shale.

Horizon and localities.—16, 24, 40, 48, 49, 62, 67, 94, 95, 96; 2, 6, 7, 9, 10, 15, 17, 19, 23, 26, 27, 30, 37, 52, 55–57, 61, 64–66, 68, 69, 71, 76–78, 86, 87, 89, 92.

OISTODUS ERECTUS Stauffer, n. sp.

Plate 74, figure 50

Holotype: Geol. Mus. Univ. Minnesota, B4683.

Base slightly elongate, flattened and flaring; excavation on under side very

shallow. Cusp laterally compressed, thin and blade-like, inclined slightly forward but rising nearly vertically from base, keeled anteriorally and posteriorally. Posterior keel extends down to base and continues along its median axis to the end; anterior keel also extends to base and continues a short distance towards the front.

Horizon and locality.—40.

OISTODUS EXCELSUS Stauffer, n. sp.
Plate 74, figure 43

Holotype: Geol. Mus. Univ. Minnesota, B4676.

Base truncated in front, slightly extended to posterior, widely flaring; basal excavation a broad, relatively shallow groove that turns upward into the truncated anterior end. Cusp strong, inclined to base at angle of about 30°, slightly curved inward, with keeled edges; in cross-section broadly rounded on outer side; convex on inner side only in central portion, being flattened near anterior keel and flattened or slightly concave near posterior keel. This is a large and well marked species.

Horizon and locality.—10; 15, 26, 27, 62.

OISTODUS FORNICALUS Stauffer, n. sp.
Plate 75, figures 3–6

Types: Geol. Mus. Univ. Minnesota, syntypes, B4686–4688; paratype, B4689.

Base laterally compressed, with rounded upper posterior edge, lower or under side with a deep narrow excavation. Cusp rising from truncated anterior end of base, curving rapidly upward and backward; upper edge highly arched, lower edge nearly straight; longitudinally striate, especially on the outer side and curving slightly inward.

Horizon and localities.—57, 67, 94, 96; 40, 43.

OISTODUS GIGANTEUS Stauffer, n. sp.
Plate 74, figure 45

Holotype: Geol. Mus. Univ. Minnesota, B4678.

Base short, flaring laterally, tapering to a rounded point in front, broadly rounded at posterior; a very shallow excavation on under side, deepest near posterior margin of cusp. Blade-like cusp laterally flattened with keeled anterior and posterior edges; transverse thickness greatest near posterior edge; a slight depression paralleling anterior keel. The most striking feature of this species is its very large size.

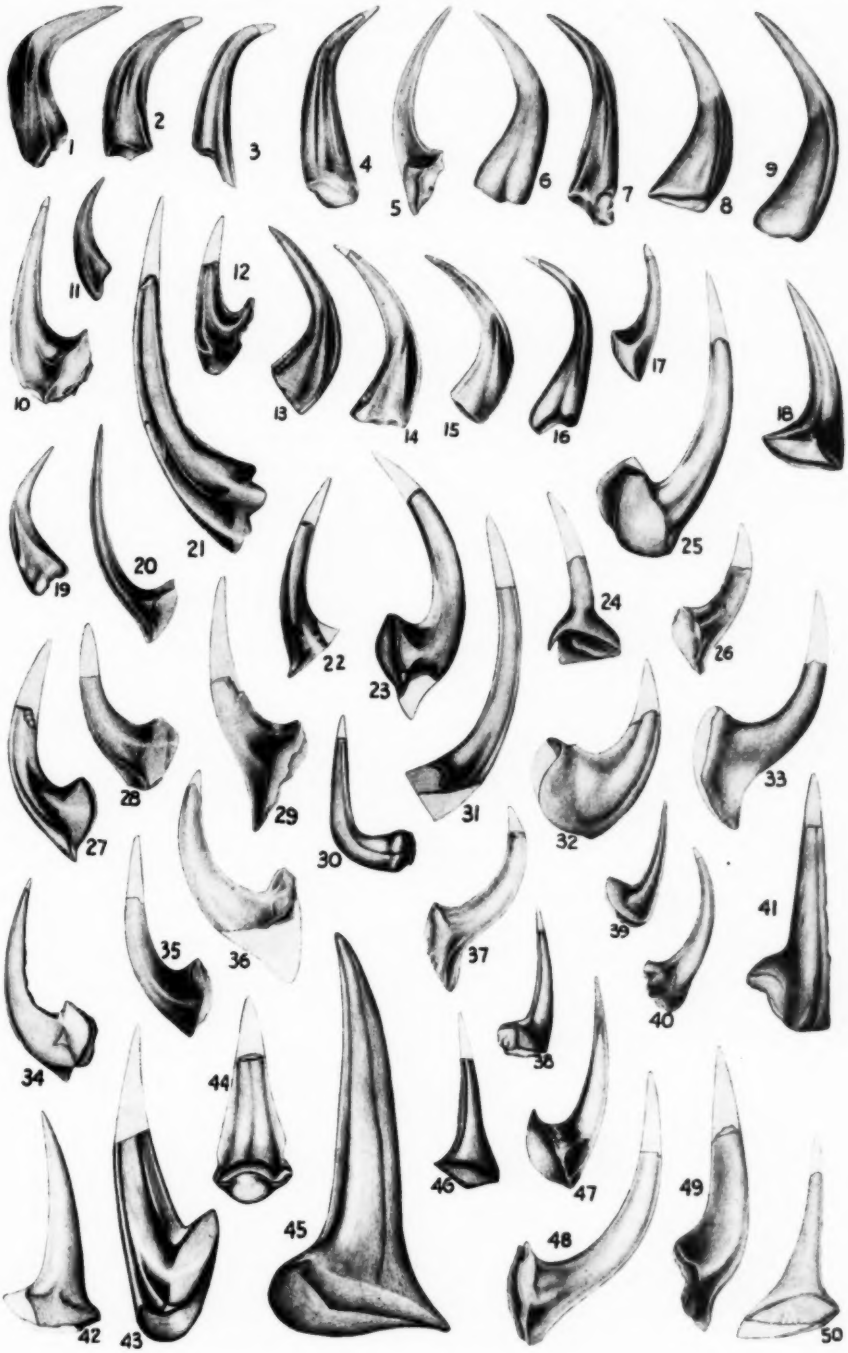
Horizon and locality.—94.

OISTODUS INCLINATUS Branson and Mehl, 1933
Plate 74, figure 41; Plate 75, figures 9, 14

Oistodus inclinatus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 110, pl. 9, fig. 8.

EXPLANATION OF PLATE 74

FIGS. 1, 2, 11, 13–15, 19—*Paltodus cornutus* Stauffer, n. sp. 1, loc. 96; 2, loc. 94; syntypes. 11, 19, loc. 94; 13–15, loc. 48; paratypes. Figs. 13–15, ×35; others, ×30. (p. 612)
3, 16—*Paltodus striatus* Stauffer, n. sp., syntypes, ×30. 3, loc. 94; 16, loc. 10. (p. 613)
4, 7—*Paltodus elegans* Stauffer, n. sp., syntypes, ×35, loc. 48. (p. 612)
6, 8, 9—*Paltodus arcuatus* Stauffer, n. sp., syntypes, ×35, loc. 94. (p. 612)
5, 10, 12, 17, 20–23, 25–29, 31, 33–40, 47–49—*Oistodus curvatus* Branson and Mehl. 5, 17, 39, loc. 67; 10, 12, 20, 26, 28, 29, 31, 35–37, 40, 48, loc. 94; 21, loc. 24; 22, 33, loc. 40; 23, loc. 49; 25, 27, loc. 62; 34, loc. 16; 38, loc. 95; 47, loc. 48; 49, loc. 96. All ×30 except figs. 5 and 31, ×35. (p. 609)
24—*Microcoelodus* sp., ×35, loc. 94. (p. 608)
18, 42, 46—*Oistodus suberectus* Branson and Mehl. 18, loc. 48, ×35; 42, loc. 40, ×30; 46, loc. 94, ×30. (p. 611)
32—*Oistodus brevis* Stauffer, n. sp, holotype, ×30, loc. 40. (p. 609)
41—*Oistodus inclinatus* Branson and Mehl, ×35, loc. 94. (p. 610)
43—*Oistodus excelsus* Stauffer, n. sp., holotype, ×30, loc. 10. (p. 610)
45—*Oistodus giganteus* Stauffer, n. sp., holotype, ×35, loc. 94. (p. 610)
50—*Oistodus erectus* Stauffer, n. sp., holotype, ×30, loc. 40. (p. 609)
30—*Distacodus falcatus* Stauffer, ×30, loc. 40. (p. 605)
44—*Acontiodus alveolaris* Stauffer, n. sp., holotype, ×30, loc. 40. (p. 601)



Stauffer, Ordovician Conodonts

Figured specimens: Geol. Mus. Univ. Minnesota, B4674; B4692, B4697.

Observation.—Base not much larger than lower end of cusp, flaring at sides, with a shallow excavation on the under side. Cusp laterally compressed, inclined to base at an angle of about 45°, gently flexed or curved inward, anterior and posterior edges keeled; cross-section of cusp slightly convex on outer side but more convex on inner side, then flattening near the edges; along front margin this flattening gives rise to a shallow longitudinal furrow.

Horizon and locality.—94; 27, 30, 40, 70, 91.

OISTODUS SUBERECTUS Branson and Mehl, 1933
Plate 74, figures 18, 42, 46

Oistodus suberectus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 111, pl. 9, fig. 7.

Figured specimens: Geol. Mus. Univ. Minnesota, B4651, B4675, B4679.

Observation.—Base short, laterally expanded into a broad flange with a shallow excavation on under side. Cusp laterally flattened, blade-like, with keeled anterior and posterior edges, curving slightly to posterior, gradually tapering to a sharp point.

Horizon and localities.—40, 48, 94; 16, 37, 64, 71, 89.

Genus OZARKODINA Branson and Mehl, 1933

Ozarkodina BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 51.

OZARKODINA CONCINNA Stauffer, 1935
Plate 71, figures 2, 4, 5, 8, 14, 17–19, 22, 26

Ozarkodina concinna STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 148, pl. 10, figs. 41, 45, 46.

Figured specimens: Geol. Mus. Univ. Minnesota, B4466, B4468, B4469, B-4472, B4478, B4481–4483, B4486, B4490.

Base slender but not thin; angle between the two limbs probably not constant but about 120° in more typical specimens. Excavation on under side, beginning at extremities, gradually widens out into a deep cavity beneath angle of base; lower edges of excavated base flare out as deeper portion is reached, on the inner side form a sharp angle at that point, with only a rounded curve on outer side.

Posterior limb may be slightly twisted, usually the shorter, commonly bearing 5 or 6 more or less discrete, sharp-pointed denticles; anterior limb bears 6 to 9 similar denticles; all denticles approach right angles with their respective limbs of base.

Cusp at apex of angle, slender, rather highly convex on outer side; this feature extending downward across the base to continue with the rounded curve of the flaring basal margin. Cusp so inclined that it is approximately parallel with posterior series of denticles.

Horizon and localities.—94, 96; 8, 11, 15, 17, 19, 24, 28, 30, 37, 40, 48, 52, 55, 61, 64, 70, 71, 74–76, 78, 86, 93.

OZARKODINA PAUPERATA Stauffer, n. sp.
Plate 71, figures 16, 24

Syntypes: Geol. Mus. Univ. Minnesota, B4480, B4488.

Base thin, flattened, in some cases slightly twisted; the two limbs forming an angle of about 135°, in some specimens greater; under side of bar with deep, narrow excavation beneath the angle which gradually narrows to a line-like groove at extremities; base shallow, upper edge sharp. Posterior limb slightly shorter, bearing 3 to 4 discrete, flattened, sharp-pointed denticles; anterior limb bears 4 to 5 similar denticles. Cusp located at angle formed by the two limbs, sharp, about twice the length of the denticles, inclined so as to be essentially parallel with posterior series of denticles. The specimens of this species available have transparent bases with translucent to white cusp and denticles. It is a rare species at most horizons but more or less common in the bentonite layer near the base of the Decorah shale.

Horizon and locality.—48; 47, 69, 85, 89, 94.

OZARKODINA ROBUSTA Stauffer, n. sp.
Plate 71, figures 1, 3, 6, 7, 9–13, 15, 21

Types: Geol. Mus. Univ. Minnesota, syntypes, B4467, B4471, B4476; paratypes: B4465, B4470, B4473–4475, B4477, B4479, B4485.

Bar or base thick, bent, the two limbs forming an angle of about 135° with each other; excavated throughout nearly entire length on under side; sides of excavation flaring out widely beneath apex of angle where cavity is deepest. Upper edges of limbs of bar slightly curved or bent out of line with each other; posterior limb the shorter, carrying 4 or 5 stout denticles; anterior limb with 7 to 10 similar denticles, all of which are deeply set in bar, partly confluent along their edges. The extent to which this latter takes place varies somewhat with different specimens.

Cusp surmounts apex of angle; short to medium in length, distinctly inclined to the posterior; the rounded angles of its lateral faces continuing downward as the angles of the flaring cavity.

This species is quite common and seems to vary considerably although nearly all gradations can usually be found in any sample.

Horizon and localities.—94, 96; 16, 22, 27, 37, 52, 68, 95.

Genus PALTODUS Pander, 1856

Paltodus PANDER, *1856*, Monographie der fossilen Fische des silurischen systems der russisch-baltischen gouvernements, p. 24.

In this genus are included all those teeth whose front or rear keels, sometimes both of them, are reduced to a plane or rounded surface, and whose lateral faces are always asymmetrical. They are very remarkable teeth which are scarcely equalled by those of living animals. [Translated.]

PALTODUS ARCUATUS Stauffer, n. sp.
Plate 74, figures 6, 8, 9

Syntypes: Geol. Mus. Univ. Minnesota, B4639, B4641, B4642.

Unit consisting of a single, blade-like cusp that tapers gradually from base to a sharp point; curved more or less evenly throughout its length, flattened on inner side, rounded on outer. Posterior or concave part of cusp sharply keeled; anterior or convex margin rounded, although there is a second keel on inner side where flattened and rounded sides meet; at mid-center the cross-section is semi-heart-shaped, pointed end being at sharp posterior keel.

On convex side, near thinner margin, a deep groove starting at a notch in base, gradually decreasing in size and depth towards apex, where it becomes a mere line. Basal excavation a slender cone that extends into cusp fully half its length.

Horizon and locality.—94; 34, 86, 87.

PALTODUS CORNUTUS Stauffer, n. sp.
Plate 74, figures 1, 2, 11, 13–15, 19

Types: Geol. Mus. Univ. Minnesota, syntypes, B4634, B4635; paratypes, B4644, B4646–4648, B4652.

Base unexpanded and the unit consisting of a single blade-like cusp, curved throughout its length. Convex side of curved cusp rounded in cross-section, concave edge sharply keeled; a well developed longitudinal groove or furrow on one side near keel, which rises from a basal notch of medium depth and gradually narrows, becoming a mere line near apex. Other side slightly depressed but not furrowed. Most specimens have such a deep groove or furrow at base that the cavity is almost cut into two parts and hence they appear to have two semi-independent conical cavities, the anterior of which is longer, tends to continue straight as the cusp curves and its apex is located near the anterior margin above the middle of the length.

Horizon and localities.—48, 94; 1, 2, 6, 11, 15, 16, 19, 24, 26, 27, 30, 37, 40, 41, 49, 65, 68, 69, 70, 74, 75, 86–88, 93, 95.

PALTODUS ELEGANS Stauffer, n. sp.
Plate 74, figures 4, 7

Syntypes: Geol. Mus. Univ. Minnesota, B4637, B4640.

Base simple, not expanded. Cusp a long slender cone, straight in lower part,

rather sharply curved above middle; one side rounded, other flat below point where curvature begins; upper third of cusp nearly circular in cross-section.

Near anterior edge of convex side a broad furrow or groove, starting from a notch in base, extending to apex where it is represented by a very fine line. There may be a shallow furrow in basal portion of flattened side also, but it extends only a short distance and then becomes obsolete.

Edges formed by rounded side sharp and keel-like; curvature of cusp is such that one of the edges or keels lies below concave side, but this passes into the rounded edge at or near middle of cusp; long, slender, cone-like excavation of base extends to sharp curve, or nearly two-thirds of length of cusp.

Horizon and localities.—48; 1, 10, 11, 15–17, 24, 26–28, 30, 37, 40, 49, 52, 61, 65, 68, 70, 71, 75, 86, 87, 92, 94, 95.

PALTODUS STRIATUS Stauffer, n. sp.
Plate 74, figures 3, 16

Syntypes: Geol. Mus. Univ. Minnesota, B4636, B4649.

Base not expanded, unit consisting of a long slender cone-like cusp which curves gently in lower part but rather sharply towards point. Near apex of cusp cross-section circular, but in lower portion there is a rounded fold on concave side of curve that rises gradually towards base and is bounded on either side by broad shallow furrows. These features more prominent near base where ridge continues as a projection below the other portion. The fold itself may have several lateral or secondary ridges and a narrow line-like groove along the top. Adjacent to furrows there may be keels which are more pronounced in mid portion of cusp. Whole surface finely striated. Basal excavation tapers gradually; its apex well above mid length of cusp.

Some specimens are slightly twisted and the curvature may be even more pronounced than that shown in the figures.

Horizon and localities.—10, 94; 16, 22, 37, 40, 51, 52, 62, 68, 70, 86, 87, 91, 93.

Genus PHRAGMODUS Branson and Mehl, 1933

Phragmodus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 98.

PHRAGMODUS COGNITUS Stauffer 1935

Plate 72, figures 27, 28, 33–37, 39–45, 50

Phragmodus cognitus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, pp. 150, 151, pl. 11, figs. 12–14, 18, 31, 41.

Figured specimens: Geol. Mus. Univ. Minnesota, B4542, B4543, B4548, B4549, B4550–4552, B4554–4560, B4565.

Observation.—This species occurs abundantly in the Decorah shale. There is some variation in the number of denticles, and also in shape, size and thickness of specimens, but they appear to grade into each other. The series here shown is a fair indication of what may be expected.

Horizon and localities.—48, 94, 95, 96; 1, 2, 6, 9, 10, 15, 16, 19, 22, 24, 26–28, 30, 37, 40, 47, 49, 51, 52, 55–57, 61–63, 65, 68–71, 74, 75, 77–79, 86–89, 92, 93.

Genus PLECTODINA Stauffer, 1935

Plectodina STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 152.

PLECTODINA DILATA Stauffer, 1935
Plate 73, figure 51

Plectodina dilata STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 152, pl. 11, figs. 43, 47.

Figured specimen: Geol. Mus. Univ. Minnesota, B4625.

Observation.—A rather large specimen showing the open sheath-like base and the cusp with its keeled edges oriented at right angles to the denticulated edge.

Horizon and localities.—47; 6, 10, 26, 30, 70.

Genus POLYCAULODUS Branson and Mehl, 1933

Polycaulodus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 86.

POLYCAULODUS CHATFIELDENSIS Stauffer, n. sp.
Plate 71, figure 44

Holotype: Geol. Mus. Univ. Minnesota, B4508.

Base thick, wide, tapering to ends, deeply arched or notched on under side but not excavated; bottom of notch with broad carina extending from end to end of base; margins of notch form a thick ridge that rises from extremities of base to base of crest, where it forms a rounded curve; upper edge of the base broadly rounded, bearing a long stout cusp on highest portion; to right two short, stout denticles, to left one elongate denticle; left side broken, complete specimen doubtless had one or two more denticles.

Horizon and locality.—62.

POLYCAULODUS IRREGULARIS Stauffer, n. sp.
Plate 75, figure 18

Holotype: Geol. Mus. Univ. Minnesota, B4701.

Base slightly elongate, wider in front, rounded at both ends; under-side with a shallow excavation. Cusp and 3 or 4, possibly more, unequal denticles irregularly distributed over upper surface; cusp slightly flattened laterally, keeled on the anterior edge; cusp and denticles thickened or buttressed on one side, probably outer; ridge-like thickening extends downward to lower edge of base.

Horizon and localities.—94; 26.

POLYCAULODUS sp.
Plate 75, figure 35

Figured specimen: Geol. Mus. Univ. Minnesota, B4716.

A fragmentary but most unusual specimen. The fragment suggests symmetry, hence the restoration given.

Base elongate, pointed at both ends, nearly straight on under side, flattened on outer side but notched in front on highly arched inner side. Cusp slender, laterally flattened with keeled edges and much thickened base. Limbs of bar very short but apparently with a single distant denticle near the ends.

Horizon and locality.—37.

EXPLANATION OF PLATE 75

FIGS. 1—*Pteroconus gracilis* Branson and Mehl, ×30, loc. 70. (p. 617)
15–17, 20, 21—*Pteroconus robustus* Stauffer. 15, loc. 52; 16, 20, 21, loc. 94; 17, loc. 24. Figs. 16, 21, ×35; others, ×30. (p. 617)
2, 7, 11–13, 19—*Oistodus abundans* Branson and Mehl. 2, loc. 67; 7, 12, 13, oc. 48; 11, loc. 40; 19, loc. 37. All ×30 except fig. 7, ×35. (p. 609)
3–6—*Oistodus fornicalus* Stauffer, n. sp. 3, loc. 96; 4, loc. 57; 5, loc. 94; syntypes, ×30. 6, loc. 67, paratypes, ×35. (p. 610)
9, 14—*Oistodus inclinatus* Branson and Mehl, ×30, loc. 94. (p. 610)
8—*Dichognathus variabilis* Stauffer, n. sp., paratype, ×35, loc. 94. (p. 604)
10—*Dichognathus?* sp., ×30, loc. 94. (p. 605)
18—*Polycaulodus irregularis* Stauffer, n. sp., holotype, ×35, loc. 94. (p. 614)
35—*Polycaulodus* sp., ×35, loc. 37. (p. 614)
22—*Trichognathus recurvus* Branson and Mehl, ×30, loc. 40. (p. 619)
25, 26—*Trichognathus symmetricus* Stauffer, n. sp., holotype, ×35, loc. 67. 25, bottom view; 26, top view. (p. 620)
23, 28–31, 37—*Polyplacognathus ramosus* Stauffer, n. gen. and sp., ×30. 29, loc. 40; 30, 31, loc. 24; syntypes. 23, loc. 40; 28, 37, loc. 17; paratypes. (p. 615)
27, 33—*Polyplacognathus expansus* Stauffer, n. gen. and sp., holotype, ×30, loc. 40. 27, bottom view; 33, top view. (p. 615)
32, 36, 38, 43, 48, 49, 62, 63—*Polyplacognathus* sp. *a*, ×30, loc. 40. (p. 615)
39, 42, 44, 47—*Polyplacognathus?* sp. *b*. 39, 44, 47, loc. 24; 42, loc. 40. Fig. 47, ×35; others, ×30. (p. 616)
24—*Ancyrognathus?* sp. *a*, ×30, loc. 40. (p. 602)
60, 61—*Ancyrognathus?* sp. *b*, ×30, loc. 40. (p. 602)
34, 40, 41, 45, 46, 50–52, 57, 58—*Scyphiodus primus* Stauffer, n. gen. and sp., syntypes, ×30. 34, 40, 46, 50–52, loc. 40; 41, 45, 57, 58, loc. 37. (p. 617)
53—*Polygnathus?* sp., ×30, loc. 40. (p. 615)
59—*Prioniodus* sp., ×30, loc. 89. (p. 617)
54–56—Egg cases?, ×30, loc. 40. (p. 620)

Stauffer, Ordovician Conodonts

Genus POLYGNATHUS Hinde, 1879

Polygnathus HINDE, *1879*, Geol. Soc. London, Quart. Jour., vol. 35, pp. 361, 362.

POLYGNATHUS? sp.
Plate 75, figure 53

Figured specimen: Geol. Mus. Univ. Minnesota, B4733.

A fragmentary specimen of rather indefinite classification, consisting of a thick elongate plate. The under side shows a longitudinal ridge crossed by numerous irregularly spaced curved lines with their convex curvature towards the more pointed end. The upper surface shows a rough irregular nodose ridge running the full length of the specimen, to one side (lower, in the drawing) of the central axis. The general upper surface is nodose but without very definite pattern.

Horizon and locality.—40.

Genus POLYPLACOGNATHUS Stauffer, n. gen.

Asymmetrical dental plates of few or many lobes, the larger of which tend to be wing-like. Under surface of plates smooth except for furrows, ridges, and growth-like lines; upper surface of each lobe has, or tends to have, a median nodose ridge, on both sides of which are less definite nodose ridges or groups of nodes and denticles. Any of these ridges may become a series of short stubby denticles or may be formed by the lateral union of such a dental series. These ridges radiate irregularly from a central point which appears to be more or less the center of development of plate.

Genotype: *Polyplacognathus ramosus* Stauffer, n. sp.

POLYPLACOGNATHUS EXPANSUS Stauffer, n. sp.
Plate 75, figures 27, 33

Holotype: Geol. Mus. Univ. Minnesota, B4709.

Dental plate broadly expanded, larger of main lobes wing-like, smaller broken off. Four lateral lobes, of which one is partially broken and gone. Under side of the only specimen is still attached to skeletal material but shows very high median ridges on the lateral lobes; main lobes probably had similar but less prominent median ridges.

Upper surfaces of lateral lobes occupied by high crenulated ridges; main lobes have more or less discontinuous central knobby ridges, but the prominent feature of these larger lobes is the transverse ridging.

Horizon and locality.—40.

POLYPLACOGNATHUS RAMOSUS Stauffer, n. sp.
Plate 75, figures 23, 28–31, 37

Types: Geol. Mus. Univ. Minnesota; syntypes, B4711–4713; paratypes, B4706, B4710, B4718.

Elongate dental plates with four slender lateral lobes that curve downward and taper to blunt points. Under side shows well-marked central ridges running out along each lobe, uniting in a tangle at center or junction of all lobes; also a series of lines, resembling growth lines, parallel to the under margins of lobes.

Downward curving lobes bear on their upper sides high, or sometimes thick, ridges formed by lateral fusion of denticles. One of main lobes may be smaller; that best preserved has a rather prominent denticulated ridge extending to tip of lobe and a less perfectly developed parallel ridge that becomes obsolete before reaching tip; margin then more or less outlined by small denticles; occasional scattered denticles or nodes between; deep furrows may separate these denticular ridges. The fragment of smaller main lobe shows a central denticular ridge and other denticles of less definite arrangement. Number of denticles in these ridges seems to be quite variable.

Horizon and localities.—24, 17, 40; 4.

POLYPLACOGNATHUS sp. *a*
Plate 75, figures 32, 36, 38, 43, 48, 49, 62, 63

Figured specimens: Geol. Mus. Univ. Minnesota, B4714, B4717, B4719, B4723, B4728, B4729, B4741.

Observation.—Fragmentary pieces of

indeterminate species belonging to this genus. All show denticulated or crenulated ridges, and on their under sides the characteristic surfaces.

Horizon and locality.—40.

POLYPLACOGNATHUS? sp. *b*
Plate 75, figures 39, 42, 44, 47; Plate 72, figures 8, 11, 12, 16

Figured specimens: Geol. Mus. Univ. Minnesota, B4523, B4526, B4527, B4531, B4720, B4724, B4727.

These are long slender lobes broken from some larger plate and probably constitute the more slender lobe of *Polyplacognathus ramosus*. In fact the specimen represented by figure 44 might have been broken from the right side of the one shown in figure 30. These fragments show the median ridge and lines characteristic of the under side of that species. On the upper surface they show a central denticulated ridge in which the individuals increase in height towards the outer tip and are angular in cross-section. Some additional rows of denticles come in near the margins at the broader end. In these the transverse edges may unite with those of the central row and form rough ridge-like elevations.

Horizon and localities.—24, 40.

Genus PRIONIODUS Pander, 1856

Prioniodus PANDER, *1856*, Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements, p. 29. —ULRICH and BASSLER, *1926*, U. S. Nat. Mus., Proc., vol. 68, art. 12, pp. 8, 9.

By this name are covered all those teeth or jaws from which a very large tooth protrudes above the surrounding tissue, and which is bordered on one side by a series of smaller teeth. The hollow of the base extends lengthwise under all these teeth and up into them to a certain height. [Translated.]

Ulrich and Bassler add somewhat to this description by the following comments:

Typically the pick shape is well developed in this genus, the main terminal cusp relatively large with both edges sharp. The basal extension, although variable in length, is usually strong and often as long as the cusp itself, the anterior line formed by both being nearly straight. Numerous denticles on the bar, their lower half or more sometimes fused, but in some cases, although always closely arranged, they remain discrete to the junction with the bar.

PRIONIODUS ACULEATUS Stauffer, 1932
Plate 73, figures 46, 52, 54

Prioniodus aculeatus STAUFFER, *1932*, Jour. Paleontology, vol. 6, p. 259, pl. 40, fig. 2.

Figured specimens: Geol. Mus. Univ. Minnesota, B4620, B4626, B4628.

Observation.—The oral view of this species shows a deep, narrow basal cavity with the anterior keel of the cusp forming a sharp edge along the front. There may have been a half dozen or more small sub-equal denticles on a perfect specimen.

Horizon and localities.—57, 67; 47, 62, 86, 91, 95.

PRIONIODUS CRISTULUS Stauffer, 1932
Plate 73, figures 48, 49, 57, 58

Prioniodus cristulus STAUFFER, *1932*, Jour. Paleontology, vol. 6, p. 260, pl. 40, fig. 50.

Figured specimens: Geol. Mus. Univ. Minnesota, B4622, B4623, B4631, B4632.

Observation.—Robust specimens showing a sheath-like base, one still retaining part of the skeletal element to which it was attached.

Horizon and localities.—94; 5–7, 10, 15, 16, 19, 24, 27, 37, 40, 47, 52, 67, 70, 71, 78, 79, 86, 88, 91, 92, 95.

PRIONIODUS LIRATUS Stauffer, 1935
Plate 72, figure 38

Prioniodus liratus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 153, pl. 10, fig. 8.

Figured specimen: Geol. Mus. Univ. Minnesota, B4553.

Observation.—The specimens belonging to this species cannot be distinguished from those found in the Glenwood beds.

Horizon and locality.—94.

PRIONIODUS sp.
Plate 75, figure 59

Figured specimen: Geol. Mus. Univ. Minnesota, B4739.

Base or bar laterally compressed, slightly curved inward, becoming thinner towards the posterior; under side a sharp keel but showing some slight indication of developing a cavity at the broken anterior end. Upper margin set with a series of 12 to 16 or more, closely packed, slender, inclined denticles that are confluent at the base and show nearly half their length embedded in the translucent bar; a lateral carina along the side of the denticles marks the top of the bar. This latter passes into the expanded bar towards anterior.

Horizon and locality.—89.

Genus PTEROCONUS Branson and Mehl, 1933

Pteroconus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 99.

PTEROCONUS GRACILIS Branson and Mehl, 1933
Plate 75, figure 1

Pteroconus gracilis BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 111, pl. 8, figs. 28, 30, 32, 35.

Figured specimen: Geol. Mus. Univ. Minnesota, B4684.

Base rather small, highly arched, laterally much more convex on outer side. Excavation greatest beneath cusp; in this specimen still filled with a skeletal fragment. Cusp long, tapering to a graceful point, slightly curved posteriorally, bending strongly inward; just above base on outer side the median ridge-like portion of cusp extends down across base and has notch-like concavities on either side; there may be a very slight furrow on the outer side running the length of the cusp. Cross-section of cusp shows anterior and posterior sharp edges, an inner flattened convexity, an outer strong convexity. Only remnants of one or two anterior denticles, and one posterior denticle are preserved.

Horizon and locality.—70.

PTEROCONUS ROBUSTUS (Stauffer) Stauffer
Plate 75, figures 15–17, 20, 21

Euprioniodina robusta STAUFFER, *1930*, Jour. Paleontology, vol. 4, p. 123, pl. 10, fig. 1.

Figured specimens: Geol. Mus. Univ. Minnesota, B4698–4700, B4703, B4704.

Better material than that from which the original description was written indicates that this species does not belong to *Euprioniodina* but to *Pteroconus*.

Base short, consisting of a posterior and a lateral bar which meet nearly at right angles; under side of base excavated throughout its extent but beneath cusp excavation expands into a broad deep cavity with flaring inner edge. Cusp curved, broad, laterally flattened, with keeled edges; Cusp oriented with its flattened faces about 80° out of line with the posterior limb; cusp quite variable in length and width. Denticles closely set on the posterior bar but widely spaced on the lateral or inner bar.

Horizon and localities.—24, 52, 94; 5, 8, 9, 62.

Genus SCYPHIODUS Stauffer, n. gen.

Rough-surfaced dental units with bar-like base tapering gradually to anterior but rather abruptly to posterior. Under side of base narrow, the grooved excavation beginning at anterior and expanding into a deep rounded cavity at posterior beneath cusp. Upper surface wide, with three rows of widely spaced teeth that have lateral edges confluent across from row to row, giving the appearance of transverse ridges. Cusp short, posteriorally directed.

Genotype: *Scyphiodus primus* Stauffer, n. sp.

SCYPHIODUS PRIMUS Stauffer, n. sp.
Plate 75, figures 34, 40, 41, 45, 46, 50–52, 57, 58

Syntypes: Geol. Mus. Univ. Minnesota, B4715, B4721, B4722, B4725, B4726, B4730, B4731, B4737, B4738.

Base bar-like, wider at top than at bottom, tapering to anterior; under side

rather deeply excavated throughout its entire length; beginning as a very narrow groove at anterior, the excavation gradually widens out; at posterior end becomes a deep cavity with rounded flaring edges.

Upper surface tapers to both ends but rather abruptly at posterior where the short, sharp cusp surmounts the larger end of the basal excavation and points slightly to the posterior; 3 rows of widely spaced denticles, more or less confluent along their adjacent edges, giving somewhat the appearance of 6 or 7 cross-ridges; middle row may have one or two extra denticles immediately in front of cusp or principle denticle; outer rows project more or less beyond margin of dental surface.

Horizon and localities.—40, 37; 94.

Genus SUBCORDYLODUS Stauffer, 1935

Subcordylodus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 153.

SUBCORDYLODUS? INAEQUALIS Stauffer, n. sp.
Plate 73, figures 2, 3, 17, 22, 26

Types: Geol. Mus. Univ. Minnesota, syntypes, B4576, B4577, B4600; paratypes, B4591, B4596.

Base slender, gradually thinning to posterior; under side grooved or furrowed throughout its length, at anterior passing into a deep, laterally compressed, conical excavation, the apex of which passes into base of cusp. Upper edge of bar bears a series of 6 to 8, possibly more, slender, backwardly directed, discrete denticles, that increase in length and become more distantly spaced towards posterior end. Cusp slender, laterally compressed, keeled in front, regularly arched, extending below base about half as far as it does above; that portion below base forms sharp anterior margin of the sheath. This species fails in some respects to meet the requirements of the genus to which it is referred. Its cusp is very slightly, if at all, oriented out of line with the denticles.

Horizon and localities.—48, 94; 16, 40, 49, 57, 70, 71.

SUBCORDYLODUS RECTILINEATUS Stauffer, 1935
Plate 73, figures 7, 23, 28, 29, 33, 39

Subcordylodus rectilineatus STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 154, pl. 11, figs. 30, 32.

Figured specimens: Geol. Mus. Univ. Minnesota, B4581, B4597, B4602, B4603, B4607, B4613.

Observation.—Although there is some variation in the specimens referred to this species, no very distinct line can be drawn between them. Part of the variation is due to differences in size or robustness and may mean differences in age.

Horizon and localities.—52, 67, 94; 37, 48, 57, 79, 89, 92.

SUBCORDYLODUS sp.
Plate 73, figure 21

Figured specimen: Geol. Mus. Univ. Minnesota, B4595.

Observation.—Fragment of a large form with a massive, strongly curved cusp. In the cross-section of the cusp the radius of the curvature of the inner face is about half that of the curvature of the outer face.

Horizon and locality.—94.

Genus SUBPRIONIODUS Smith, 1905

Subprioniodus SMITH, *1905*, Nat. Hist. Soc. Glasgow, Trans., n. ser., vol. 7, pt. 3, p. 247.

This genus differs from *Prioniodus* Pander in that the spike at the end of the beam is sharp-pointed above the beam, but not below it.

SUBPRIONIODUS HAMATUS Stauffer, 1932
Plate 73, figure 55

Subprioniodus hamatus STAUFFER, *1932*, Jour. Paleontology, vol. 6, p. 261, pl. 40, fig. 18.

Figured specimen: Geol. Mus. Univ. Minnesota, B4629.

Observation.—This form resembles very closely the Kansas species to which it is referred. It is a rather thin and delicate specimen with deeply excavated base, and laterally compressed denticles that curve slightly towards the posterior.

Horizon and locality.—95.

Genus TRICHOGNATHUS Branson and Mehl, 1933

Trichognathus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 36.

TRICHOGNATHUS DEFORMIS Stauffer, 1935
Plate 71, figure 46

Trichognathus deformis STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, pp. 155–156, pl. 12, fig. 3.

Figured specimen: Geol. Mus. Univ. Minnesota, B4510.

Observation.—This is a basal view of a fragmentary specimen showing the usual arrangement of base, cusp and denticles, but all parts are a little more slender than in the type. The position chosen by the artist is poor for bringing out the characters of the species. However, the specimen and other fragments do not differ greatly from the type.

Horizon and locality.—96.

TRICHOGNATHUS GYROIDES Stauffer, n. sp.
Plate 71, figures 28, 43

Types: Geol. Mus. Univ. Minnesota, holotype, B4492; paratype, B4507.

Base with a strong straight limb and a more slender, highly curved or arched limb, meeting at nearly right angles; excavations of under sides of both limbs expanding into a deep cavity beneath cusp. Upper side of straight limb bears 2, or more, large denticles that project forward and upward; arched limb carries 7, or more, relatively slender denticles that curve rather abruptly inward. Cusp, rising at union of two limbs, subcircular, curving rapidly upward, its base forming an arched elevation at right angles to plane of limbs of base. Cusp broken but was probably elongate; shows several nearly obsolete carinae at base.

Horizon and locality.—69; 70, 94.

TRICHOGNATHUS ILLUSTRIS Stauffer?, 1935
Plate 71, figure 37

Trichognathus illustris STAUFFER, *1935*, Geol. Soc. Am., Bull., vol. 46, p. 156, pl. 12, fig. 4.

Figured specimen: Geol. Mus. Univ. Minnesota, B4501.

Observation.—A delicate specimen, rather small but closely resembling the type. The bars of the base are thin, slightly twisted and the cusp seems to bear a similar twist.

Horizon and locality.—56; 57, 67, 87, 89.

TRICHOGNATHUS MINNESOTENSIS Stauffer, n. sp.
Plate 71, figures 45, 50

Syntypes: Geol. Mus. Univ. Minnesota, B4509, B4514.

Two limbs of base meet at an angle of about 45°; shallow excavation of under side chiefly limited to angular space between limbs and base of cusp. Cusp elongate, stout, subcircular in cross-section, without carinae or distinct keels, slightly flattened or even furrowed at base; lower portion of cusp curves abruptly, rests on platform of basal limbs, the angle of which its plane bisects. Out of center of furrow in upper surface of basal portion of cusp rises a thin ridge that extends backward; may have a node or two on it.

Limbs of the base bear from 3 to 6 discrete, sharpened denticles that curve upward and are separated from basal extension of cusp by rounded grooves or furrows. The whole is apparently symmetrical about a plane passed through cusp perpendicular to plane of limbs.

Horizon and localities.—15, 16; 5.

TRICHOGNATHUS RECURVUS Branson and Mehl, 1933
Plate 71, figures 20, 27, 39, 41, 47; Plate 72, figures 48, 56; Plate 75, figure 22

Trichognathus recurvus BRANSON and MEHL, *1933*, Univ. Missouri, Studies, vol. 8, p. 119, pl. 10, fig. 6.

Figured specimens: Geol. Mus. Univ. Minnesota, B4484, B4491, B4503, B4505, B4511, B4563, B4571, B4705.

Observation.—These specimens seem to agree fairly well with *Trichognathus recurvus* except that the cusps are distinctly compressed laterally and the keels are poorly developed or absent. The denticles are slightly divergent but curve so as to incline slightly oral as in

the type. These differences seem more like variations in the species than characteristics establishing a new one.

Horizon and localities.—15, 52, 40; 3, 5, 8, 10, 11, 16, 17, 24, 27, 42, 48, 55, 62, 70, 71, 76, 78, 86, 89, 91, 94.

TRICHOGNATHUS SYMMETRICUS Stauffer, n. sp.

Plate 75, figures 25, 26

Holotype: Geol. Mus. Univ. Minnesota, B4708.

Base sharply angular; although one is somewhat fragmentary the two limbs of bar apparently of about same size and shape, uniting at an angle of about 80°. Limbs of bar excavated along their under sides, with a deep excavation beneath the cusp. Each limb probably bears three or more relatively small denticles. Cusp long, slender, tapering rapidly near the tip, curving abruptly at base to near right angles to plane of basal limbs. Cusp subtriangular in cross-section, slightly keeled on inner side, its curved base forming a high angular or keeled ridge at right angles to plane of basal limbs.

Horizon and locality.—67; 89.

EGG CASES?

Plate 75, figures 54–56

Figured specimens: Geol. Mus. Univ. Minnesota, B4734–4736.

Observation.—These little spherical bodies are composed of the same material as the teeth. They have no special characteristics except a circular or elliptical opening on one side. At one locality they were quite common and seemed of sufficient importance to illustrate. It is rather hesitatingly suggested that they may be egg cases, but there is no real substantiating evidence.

Horizon and locality.—40.

REFERENCES

1. STAUFFER, C. R., Decorah shale conodonts from Kansas: *Jour. Paleontology*, vol. 6, pp. 257–258, 1932.
2. KAY, G. M., Stratigraphy of the Decorah formation: *Jour. Geol.*, vol. 36, pp. 644–657, 1929.
3. WINCHELL, N. H., *Minnesota Geol. Nat. Hist. Survey, Final Rept.*, vol. 3, pt. 1, p. *l.*, 1895.
4. *Op. cit.* in note 2, p. 643.
5. STAUFFER, C. R., Mineralization of the Plateville-Decorah contact zone in the Twin City region: *Geol. Soc. Am., Bull.*, vol. 36, pp. 617–622, 1925.
6. SARDESON, F. W., Intraformational conglomerates in the Galena series: *Am. Geol.*, vol. 22, p. 318, pl. 9, 1898.
7. *Op. cit.* in note 6, p. 320.
8. *Op. cit.* in note 2, pp. 643, 644, 657.
9. EDSON, F. C., letter of October 19, 1932.
10. HINDE, G. J., On conodonts from the Chazy and Cincinnati group of the Cambro-Silurian and from the Hamilton and Genesee shale divisions of the Devonian in Canada and the United States: *Geol. Soc. London, Quart. Jour.*, vol. 35, pp. 355, 362–364, 1879.
11. SCHMIDT, HERMANN, *Palaeont. Zeitschr.*, Bd. 16, pp. 76–85, pl. 6, 1934.
12. SCOTT, H. W., The zoological relationships of the conodonts: *Jour. Paleontology*, vol. 8, pp. 448–455, pls. 58–59, 1934.
13. *Op. cit.* in note 11, p. 83, fig. 8.
14. *Op. cit.* in note 12, pp. 453–455.

FORAMINIFERA

Their Classification and Economic Use

Second Edition

AN ILLUSTRATED KEY TO THE GENERA OF THE FORAMINIFERA

by JOSEPH A. CUSHMAN

Lecturer in Micropalaeontology, Harvard University

The two volumes, cloth bound, with 426 pages and 71 plates, sent on receipt of price, $5 express paid in U.S.A.; $6 postpaid, Foreign.

Contributions from the Cushman Laboratory for Foraminiferal Research.

A quarterly publication devoted to the Foraminifera.
Volume 10 now being issued. Subscription $2.50 per year, postpaid

Price list of available foraminiferal literature sent on request.

CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

SHARON, MASS., U.S.A.

MICROSCOPIC SLIDES · *The Satisfactory Kind*

POSTPAID

100....$2.00	500....$ 6.00	5000....$50.00
250....$3.25	1000.... 11.00	10000....$90.00

Send for sample

PROGRESSIVE PRINTING CO.
FT. WORTH, TEXAS

MAX WEG LEIPZIG Koenigstrasse 3

NEW and SECOND-HAND BOOKS on NATURAL SCIENCE
Specialty: GEOLOGY and PALEONTOLOGY

Please demand catalogues:
Geologia regionalis (3237 items) Paleontology (6630 items) Applied Geology (7882 items)
Large stock of Paleontological periodicals, books, maps and pamphlets

MAX WEG LEIPZIG (Germany)

Do you know about our

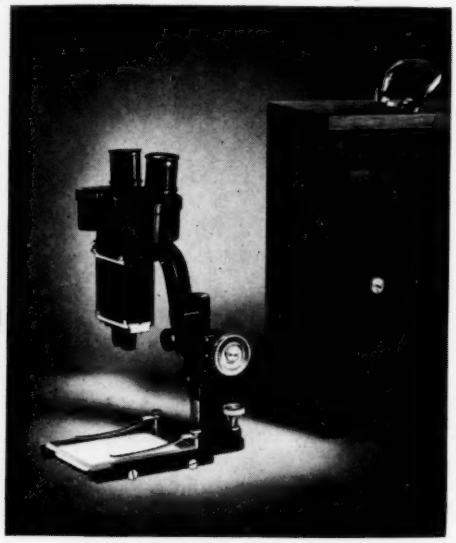
MICRO-FOSSIL SLIDES
and
SAMPLE STORAGE OUTFITS

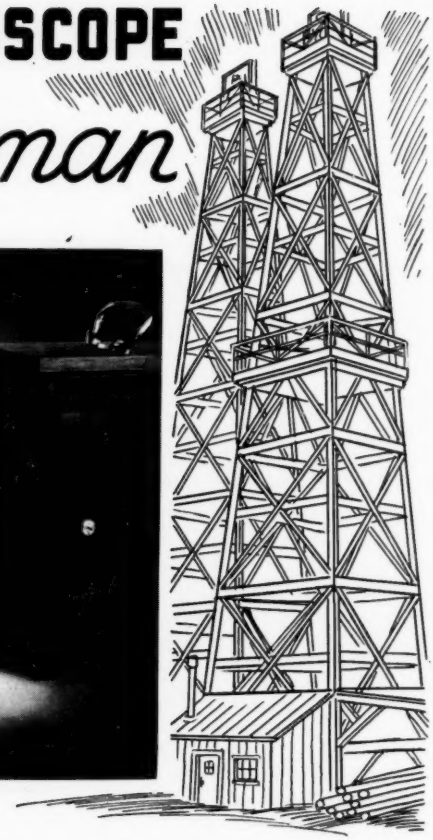
Write for details

R. P. CARGILLE
118 Liberty Street New York City, N.Y.

A WIDE FIELD MICROSCOPE

for the field man





THE strenuous conditions under which the Geologist "sitting on a well" has to work, warrants the selection of a microscope built to stand hard knocks. Since most field men prefer to accustom themselves to a single magnification, the AKW Wide Field Microscope can be furnished with a single pair of objectives. That means no extra parts to lose and more dust-proof construction. A small but rugged case completes the outfit. Its magnification of 30 times has been found to be most widely used for both paleo work and lithology.

Other magnifications and models available for laboratory work. Prices on request.

$111.50

Priced complete at $111.50, this instrument warrants your careful investigation. Details will gladly be sent on request. Bausch & Lomb Optical Co., 647 St. Paul Street, Rochester, N.Y.

Bausch & Lomb

WE MAKE OUR OWN GLASS TO INSURE STANDARDIZED PRODUCTION

FOR YOUR GLASSES, INSIST ON B & L ORTHOGON LENSES AND B & L FRAMES

ANNOUNCING
the New Spencer
JUNIOR LOW POWER BINOCULAR

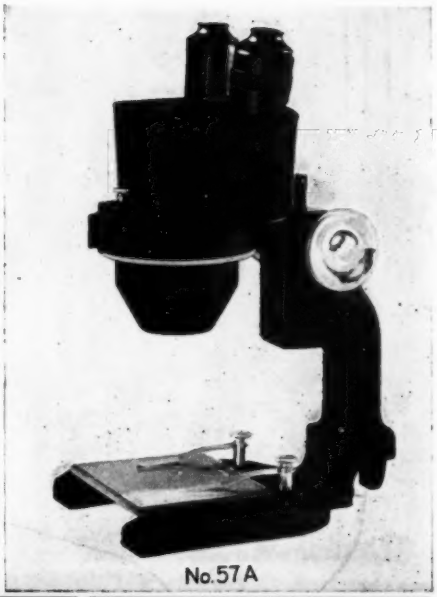
THIS Spencer No. 57 Junior Low Power Binocular is the answer to the demand, from departments where the work is more or less elementary, for a simpler and less expensive low power binocular.

This No. 57 has a simpler stand and a new, less expensive revolving nosepiece. THE OBJECTIVES ARE OPTICALLY THE SAME AS THOSE USED ON OUR HIGHER PRICED INSTRUMENTS.

The principal feature of all Spencer Low Power Binoculars is retained in the No. 57. This feature allows the observer to look into the microscope at the normal natural angle of 8° convergence for his eyes.

A new catalog M-67 gives complete description and prices of the Spencer No. 57 Junior Low Power Binocular. Write for it today. Please address Dept. D-10.

Spencer Lens Company
BUFFALO NEW YORK



There is no Substitute for the Finer Resolution Afforded by the Spencer Optical Systems

A Manual of Foraminifera

By J. J. GALLOWAY
Professor of Geology and Paleontology
Indiana University

A MONOGRAPHIC STUDY of the nomenclature, phylogeny and classification of the Foraminifera, with synonomies, complete descriptions of the families, subfamilies and genera, keys for each group, habitats and geologic ranges. The book is illustrated with 42 plates of illustrations of the genotypes of each of the 542 valid genera, and 33 phylogenetic trees. There is a brief discussion of all prveious classifications, the principles of taxonomy as applied to Foraminifera, and many of the factors in organic evolution which are well illustrated by the Foraminifera. The book is designed as a reference work for micropaleontologists and specialists on Foraminifera, and as a text.

497 pages, 6½ x 9¾. Cloth, $6.50; buckram, $7.00.

Send for a copy on approval

THE PRINCIPIA PRESS, INC.
BLOOMINGTON, INDIANA

PUBLICATIONS OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

BOX 1852 TULSA, OKLAHOMA

Geology of Natural Gas. Symposium on occurrence and geology of natural gas in North America. By many authors. 1,227 pp., 250 illustrations. 9 x 6 inches. Cloth. To members and associates, $4.50; to non-members, $6.00.

Problems of Petroleum Geology (1934). A sequel to *Structure of Typical American Oil Fields.* By many authors. 1000 + pp., 189 line drawings, 7 half-tones. 9 x 6 inches. Cloth $5.00 to members and associates; $6.00 to non-members.

Geology of California (1933). By Ralph D. Reed. 355 pp., 29 half-tones, 33 line drawings, 26 tables. 9 x 6 inches. Cloth. $5.00.

Structure of Typical American Oil Fields. Symposium on relation of oil accumulation to structure. By many authors.

Vols. I-II (1929). Descriptions of typical fields. 1290 pp., 425 illus. 9 x 6 inches. Cloth. To members and associates, $10.00; to non-members, $14.00. Either volume at half these prices.

Stratigraphy of Plains of Southern Alberta (1931). Fourteen articles reprinted from Association *Bulletin* of October, 1931. 166 pp., 60 illus. 9 x 6 inches. Cloth. $3.00.

Index to Bulletin (1927). Complete detailed index to first ten volumes of *Bulletin* (1917-1926). 9½ x 6¾ inches. Paper. $1.00.

Bulletin of The American Association of Petroleum Geologists. Official monthly publication. Each number, approximately 100 pages of articles, maps, discussions, reviews. Annual subscription, $15.00 (outside United States, $15.40). Descriptive price list of back numbers on request.

(Prices postpaid. Write for discount to colleges and public libraries.)

OFFICERS OF THE SOCIETIES

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

For the year ending March, 1936

President, W. H. TWENHOFEL, Madison, Wisconsin.

Past-President, N. L. THOMAS, Fort Worth, Texas.

Vice-President, U. S. GRANT, IV, Los Angeles, California.

Secretary-Treasurer, GAYLE SCOTT, Fort Worth, Texas.

Editor, RAYMOND C. MOORE, Lawrence, Kansas.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

For the year ending March, 1936

President, A. I. LEVORSEN, Tulsa, Oklahoma.

Past-President, WILLIAM B. HEROY, White Plains, New York.

Vice-President, FRANK A. MORGAN, Los Angeles, California.

Secretary-Treasurer, E. C. MONCRIEF, Wichita, Kansas.

Editor, LUTHER C. SNIDER, New York, New York.

Business Manager, J. P. D. HULL, Tulsa, Oklahoma.

Society Headquarters, 505 Tulsa Bldg., Tulsa, Oklahoma.

PALEONTOLOGICAL SOCIETY

For the year ending December, 1935

President, C. K. SWARTZ, Baltimore, Maryland.

Vice-President, G. D. HANNA, San Francisco, California.

Vice-President, E. S. RIGGS, Chicago, Illinois.

Vice-President, C. E. RESSER, Washington, D. C.

Secretary, B. F. HOWELL, Princeton, New Jersey.

Treasurer, C. O. DUNBAR, New Haven, Connecticut.

Editor, J. B. REESIDE, JR., Washington, D. C.

GEOLOGICAL SOCIETY OF AMERICA

For the year ending December, 1935

President, N. M. FENNEMAN, Cincinnati, Ohio.

Past-President, W. H. COLLINS, Ottawa, Canada.

Vice-President, E. S. BASTIN, Chicago, Illinois.

Vice-President, D. F. HEWETT, Washington, D. C.

Vice-President, J. B. REESIDE, JR., Washington, D. C.

Vice-President, A. F. ROGERS, Stanford, California.

Secretary, C. P. BERKEY, New York, New York.

Treasurer, E. B. MATHEWS, Baltimore, Maryland.

Society Headquarters, 419 West 117th St., New York, New York.